Waveform Processor
Type 260

CONTENTS

1. Specification 3

2. Operation 10

3. Programmable Sequences 31

4. IEEE/RS423 Control 43

5. Installation 72

6. Circuit Description 73

7. Fault Finding 75

8. Circuit Diagrams and Components Lists 76

9. Guarantee & Service Facilities 81

Index 83

Illustrations

Fig 2.1.1 Standard Volts/Time Measurement 13

Fig. 2.1.2 V wrt Voltage at Time Datum 13

Fig. 2.1.3 T to Last Crossing Point 14

Fig. 2.4.1 Pulse Width Measurement 24

Fig. 2.4.2 Definition of Area Under Curve 26

Restore. Restores a trace to its state prior to the last post-storage function.

Vertical Trace Magnification/Attenuation Multiplies trace from 0.06 to 4.00 times in 63 steps selectable by increment/decrement controls.

Trace Math. Provides the ability to add, subtract and multiply two traces and display the result in a selected trace. For multiplication the resultis scaled by selectable factors of X1, X0.5, X0.2, X0.1.

Invert. Inverts the trace about the display centre line or voltage datum.

Position. Moves the trace and datum in X and Y planes and cursor in × plane.

Integration. Calculates the indefinite integral and displays the resultant waveform. The trace is auto-scaled.

Fast Fourier Transform (FFT). Calculates the FFT of a trace. There are two windowing functions selectable - Hanning and Rectangular. Both the Amplitude and Frequency axis can be either logarithmic or linear scaling. The cursors will measure amplitude in dB or volts (see "Measurements in dB or %"), frequency will be in Hz and either Hz relative to the datum or a multiple of the frequency at the datum.The FFT will be performed on the entire display memory or the user can select 1024, 512, or 256 points. The user can also select any part of the trace using the cursor and time datum. In this case if the number of points selected is not a power of 2, the trace is "padded" to do so with values equal to the last points.

FFT Specification

The specification for frequency range and resolution is given in the table below.This gives the values for a 1024 point FFT.

To calculate the values for an n point FFT on a record of m divisions at a timebase T sec/div use the following formulae:–

Frequency range:

$$\text{Low Frequency} = \frac{1}{m * T}$$

$$\text{High Frequency} = \frac{n}{2.5 * m * T}$$

Frequency resolution = Low Frequency

Timebase Range Time/Div	Frequency Range From	To	Frequency Resolution
200s	0.5mHz	200mHz	0.5mHz
100s	1.0mHz	400mHz	1.0mHz
50s	2.0mHz	800mHz	2.0mHz
20s	5.0mHz	2.0Hz	5.0mHz
10s	10mHz	4.0Hz	10mHz
5s	20mHz	8.0Hz	20mHz
2s	50mHz	20Hz	50mHz
1s	100mHz	40Hz	100mHz
0.5s	200mHz	80Hz	200mHz
0.2s	500mHz	200Hz	500mHz
0.1s	1.0Hz	400Hz	1.0Hz
0.05s	2.0Hz	800Hz	2.0Hz
0.02s	5.0Hz	2.0kHz	5.0Hz
0.01s	10Hz	4kHz	10Hz
5ms	20Hz	8kHz	20Hz
2ms	50Hz	20kHz	50Hz
1ms	100Hz	40kHz	100Hz
0.5ms	200Hz	80kHz	200Hz
0.2ms	500Hz	200kHz	500Hz
0.1ms	1kHz	400kHz	1000Hz
0.05ms	2kHz	800kHz	2.0kHz

There is a 7MHz anti-aliasing filter in the 1602 and 1604, thus although the frequency span of the FFT will extend to 8MHz, there will be attenuation of signals beyond 7MHz in the 1602 and 1604.

Dynamic Range: For a full scale signal the following typical values were obtained:- 38dB

Amplitude Accuracy:- 4%

Number of Lines: - Dependent upon the number of points selected, Equal to ½ of the number of points selected.

POST STORAGE MEASUREMENTS

Rise/Fall Time. Calculates the rise/fall time between 10 and 90% points) signal; the 0% and 100% points are set by cursor and datum.

Set Percentage Points. The rise/fall time interval measured can be varied in 1% steps between 0% and 99% for the upper and lower points.

Overshoot. Calculates overshoot of a signal as a percent of 100% point. 0% and 100% are set by cursor and datum.

Preshoot. Calculates preshoot of a signal as a percent of 100% point. 0% and 100% are set by cursor and datum.

Frequency. Calculates the average frequency and period of a signal. The voltage datum defines the zero crossing or uses the mean of the waveform. The cursor and datum set the measured limits. Also calculates the duty cycle as a percentage

Pulse Width. Calculates the time between 50% points (or voltage datum). With the pulse "bracketed" between the time datum and cursor.

Max/Min. Displays maximum and minimum voltage excursion of a waveform relative to the vertical datum position. The cursor and datum "bracket"the waveform of interest.

Peak-Peak Calculates peak-to-peak voltage of the waveform bracketed between the time datum and cursor.

RMS. Calculates the root mean square (RMS) voltage of a waveform bracketed between the cursor and datum. The values are calculated with respect to both the voltage datum (DCRMS) and the mean of the waveform (ACRMS)

Measurement in dB or %. Voltage measurements can be displayed in dB or as a percentage with respect to a user defined reference voltage. It will also display voltages in dB relative to 1V (dBV).

Cursor Modes. The cursor will measure voltages and times relative to the voltage and time datum which can be positioned to any point on the display.

Voltage at Time Datum. The cursor will measure voltages and times relative to the point at which the time datum crosses the trace.

Delta Time Mode. The Measurement is made from the first intersection after the time datum to the last intersection preceding the cursor. Intersection points are set where the trace crosses the voltage datum.

PROGRAMMABLE SEQUENCE.

This enables a sequence of up to 24 keypresses to be entered and executed. Functions incorporated in the sequence are Capture & Repeat, numeric keypad/soft keys and any of the keys associated with the entry and execution of a programmable sequence. Entry of a sequence is through the Learn command. A sequence can be subsequently edited. There is a print command which enables the internal plotter (needs option 104 installed) to print the results. Measurement results can also be scrolled on the display during execution of the sequence.

ARCHIVING

Plot. This function is the same as the PLOT function in the 1600.

Print This will print the measurement results together with date and time to the internal plotter (needs option 104 installed).

Reference Memory. Additional reference memories are available within the waveform processor module. Up to 50 × 1Kword or 5 × 10K word memories configured from the menu. The waveform processor module can be detached without losing the waveform data. Memory Retention > 3 Months.

SAVE TRACE - ALL

All displayed input channel traces are automatically stored in the reference memories in sequence and labelled with the input channel number and date.

SAVE TRACE - ONE

The input channel trace selected by the cursor will be automatically stored in a reference memory labelled with channel number and date.

REALTIME CLOCK. 24 hour and date set via menu. Plotted with digital output plots for record of acquisition time. Time is retained for at least 3 months with the power disconnected.

PROGRAMMABILITY. All functions can be accessed via the IEEE-488 or RS-423 interface.

1600 SERIES SOFTWARE COMPATIBILITY

The Gould 1600 Series of Digital Storage Oscilloscopes and the options have had additional features introduced at different stages since their introduction. To operate the instruments to the full specification the software compatibility listed in the table must be observed.

SOFTWARE COMPATIBILITY IS INDICATED BY THE FIRST DIGIT AFTER THE DECIMAL POINT.

No permanent damage can be caused by connecting options with the incorrect software versions.

Ordering:

When ordering additional optional facilities, please quote the instrument serial number and indicate the Main Instrument Software Version with the order. The software version number is shown on the display when the instrument is first switched on.

1600 SERIES SOFTWARE VERSION COMPATIBILITY TABLE

1602 or 1604 MAIN INSTRUMENT	260 WAVEFORM PROCESSOR	105 MEMORY MODULE	102 INTERFACE	103 INTERFACE	103A INTERFACE
2.42 2.43	1.42	1.42	1.41	1.41	NOT COMPATIBLE
2.52 3.53	3.50	1.52	1.52 2.52 3.53	1.52	2.52 3.53

2.0 OPERATION

Topics: Installation and checking
initialising the waveform processor

Keys: F (function)
INITIALISE
numeric and datum movement keys

General

The 260 Waveform Processor is for use with the Gould 1600 series Digital Storage Oscilloscopes to capture, manipulate and manipulate waveforms.

2.0.1 Connection

Disconnect the 1600 from the AC supply.

Connect the 260 Waveform Processor interface to either of the rear panel connectors and tighten the fixing screw until the interface is securely fitted.

The 260 Waveform Processor keypad should then be connected to the interface.

To check the interface has been connected correctly switch on the 1600 and the on screen alphanumerics will display the message

VERSION X.XX + KEYPAD X.XX

This indicates that the 260 Waveform Processor is connected and recognised by the instrument.

Check that the waveform processor is working correctly by pressing the 'SELECT TRACE' key on the keypad, selecting cursors on a displayed trace. The datum and the cursor will be close to the left and right edges of the screen respectively and the reading will be of the form

CH1: 2.5mV 1.23ms

The exact values will depend upon the particular waveform being measured and the voltage and timebase ranges selected.

2.0.2 Waveform Processor Functions

F (function) The BLUE '2nd level' key is used to select the corresponding 2nd level functions, also printed in blue, available on many of the keys.

Initialise Initialises the Waveform Processor functions. This includes resetting averaging, enveloping and filtering to zero, cancelling TV mode triggering, turning off any limit or enveloped traces and

changing the cursor measurement to voltage and time.

NOTE:- Pressing 'INITIALISE' will NOT delete any programmed sequence present in the waveform processor.

2.0.3 Numeric and Datum Keys

The numeric keys on the keypad operate in an identical manner to the corresponding numeric keys on the 1600. They can call up and make selections in all menus and can be used to enter numeric values such as trigger delays.

The datum movement keys on the keypad can be used to make selections in menus in the same way as the datum keys on the front panel of the 1600.

2.0.4 Double Speed Keys

Certain keys on the waveform processor keypad have two speeds of operation. These are 'INC', 'DEC', ◄, ►, ▲, ▼, 'CURSOR◄', and 'CURSOR►'. For example, pressing the 'INC' key will increment the Y magnification by a small amount. Fully depressing 'INC' will increment by a much larger step. Similarly, pressing 'CURSOR◄' will move the cursor one position to the left. Fully depressing 'CURSOR◄' will move the cursor by a larger amount.

2.1 Time and Voltage Measurement

Topics: time and voltage measurement modes
voltage datum, time datum and cursor

Keys: CURSOR
CURSOR MODE
DATUM
SELECT TRACE
V&T

The 1600 has three on screen lines for measurements :-

VOLTAGE DATUM This is a horizontal dashed line which can be moved over the height of the screen. Cursor voltages are measured with respect to this datum.

TIME DATUM This is a vertical dashed line which can be moved over the width of the screen. Cursor time measurements are made with respect to this datum.

CURSOR This is a short line which can be moved horizontally and which follows the trace in Y. The intersection of the trace and the cursor is the reference point for measurements made on the selected trace. The alpha-numeric display at the bottom of the screen indicates voltages at this point measured with respect to the voltage datum and the time to this point measured with respect to the time datum.

2.1.1 Cursor and Datum Movement

Select Trace Operation of this key turns on the cursor, the voltage datum and time datum. Subsequent presses step through the displayed traces and the off position.

Displayed waveforms to be measured or processed are identified by the measuring cursor in this manner.

Datum After pressing the 'DATUM' key the four arrow keys control the position of the voltage datum and the time datum. A second press, while the message

PRESS AGAIN TO SET DATUM

is displayed, will set the voltage and time datum to the current cursor position, zeroing the measurement readings.

Cursor Operating the CURSOR ◄ and ► controls enables the cursor to be moved horizontally and positioned at any point on the trace to make a measurement.

2.1.2 Cursor Measurement Modes

The 'CURSOR MODE' key is used to select the type of measurement used when calculating the voltage and time values displayed. Operating this key displays the current cursor measurement mode. Subsequent presses will step through the modes available. When the 1600 is switched on the waveform processor calculates voltage and time measurements based on the following diagram.

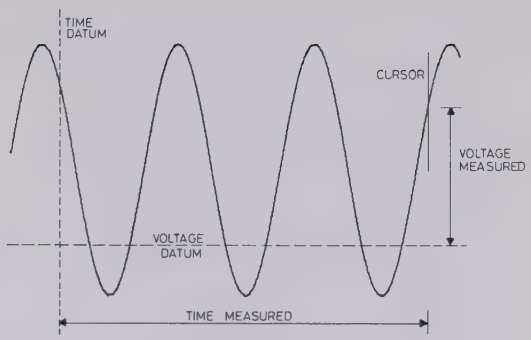


Fig. 2.1.1 Standard Volts/Time Measurement

This is described as

V wrt VOLTAGE DATUM

(voltage with respect to the voltage datum) when the cursor mode key is pressed.

A subsequent key press while the above message is displayed will select a mode that calculates voltage and time measurements with respect to the point at which the time datum crosses the trace.

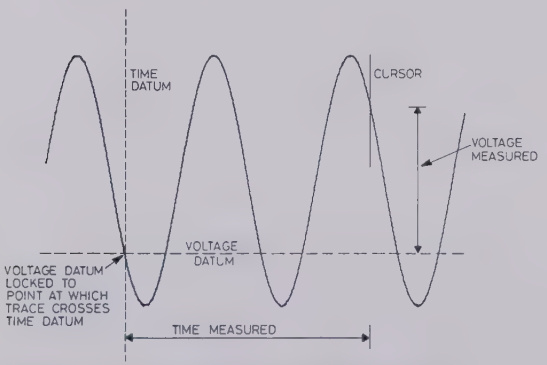


Fig. 2.1.2 V wrt VOLTAGE AT TIME DATUM

This is described as

V wrt VOLTAGE AT TIME DATUM

A further press selects the third measurement mode. The displayed result is the time from the time datum to the last point at which the trace crosses the voltage datum before the cursor. The measurement must always be positive and is made from the time datum towards the cursor as shown in fig. 2.1.3. If the trace does not cross the voltage datum between the time datum and the cursor a value of 0 sec is shown.

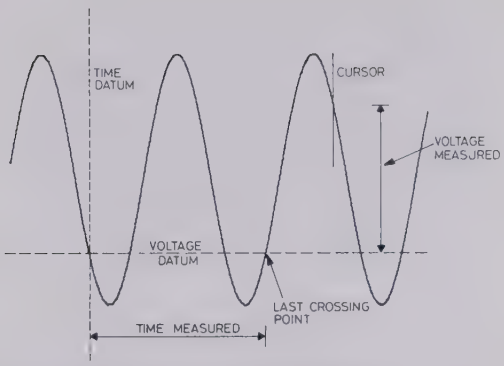


Fig. 2.1.3 T TO LAST CROSSING POINT

This mode is described as

T TO LAST CROSSING POINT

on the screen.

NOTE:- In the ' V wrt VOLTAGE AT TIME DATUM' mode the voltage datum is fixed to the point at which the trace crosses the time datum. It therefore indicates the reference point for all voltage measurements. In this mode the voltage datum cannot be moved using the normal voltage datum controls. An attempt to do so will produce the message

VOLTAGE DATUM LOCKED

The level of the voltage can only be changed by moving the time datum.

2.1.3 V&T

Pressing the 'V&T' (Volts and Time) key is equivalent to selecting VOLTAGE wrt VOLTAGE DATUM using the 'CURSOR MODE' key and selecting STANDARD UNITS using the 'dB/%' key (see section 2.4.9). This cancels any other measurement mode and restores cursor measurement to its power on state.

2.2 Acquisition Functions

Topics: acquiring traces
averaging
enveloping
tv line selection and capture
limits testing

Keys: ABORT
CAPTURE
CAPTURE AND REPEAT
SAVE UPPER LIMIT
SAVE LOWER LIMIT
SET AVERAGE
SET ENVELOPE
TEST LIMITS
TV LINE
TV MODE
WAIT

The following waveform processor functions affect the way in which the 1600 captures traces.

2.2.1 Capture

Pressing the 'CAPTURE' key will 'arm' the 1600 to complete a capture after receiving the next trigger. Holding down this key will continuously re-arm the 1600 to accept triggers and update the display. If averaging has been selected, pressing 'CAPTURE' will result in the set number of traces being captured and averaged. For example, if averaging of 8 traces is selected the pressing 'CAPTURE' will cause 8 traces to be acquired and the running average of these traces will then be displayed. Similarly, if enveloping has been selected, pressing 'CAPTURE' will cause the set number of traces to be acquired and an envelope of their maximum and minimum values created.

2.2.2 Capture and Repeat

Pressing the 'CAPTURE AND REPEAT' key will arm the 1600 to complete a capture after the next trigger and then perform the last selected post-storage function. The execution of a programmable sequence is regarded as a post-storage function. Therefore, if the last function was the execution of the programmable sequence, then pressing 'CAPTURE AND REPEAT' will result in a further acquisition followed by the re-execution of that sequence.

NOTE:- It is advisable to press 'INITIALISE' to reset the waveform processor prior to selecting the required post-storage function. When using 'CAPTURE AND REPEAT' the current measurement mode will be restored after the post-storage function has been performed.

NOTE:- If the currently selected trace is a reference trace the effect of pressing 'CAPTURE AND REPEAT' may not be as expected as 'CAPTURE' does

not alter the reference traces. Therefore the last post-storage function will be performed using the current contents of the selected reference trace.

2.2.3 TV Mode

Pressing the 'TV MODE' key will set up the 1600 trigger system to trigger on a TV line. Triggering will depend upon the TV standard (PAL, NTSC or SECAM) selected in the Special Functions menu. 'TV LINE' is used to select the required line. Pressing 'INITIALISE' will return the trigger system to the settings prior to the selection of TV mode.

2.2.4 TV Line

Enables the current TV line to be changed by using the 'INC' (increment) and 'DEC' (decrement) keys. The 'INC' and 'DEC' controls have three speeds of operation: single step, by pressing the key once; first step slow, achieved by keeping the key depressed so that it repeats; and fast, by fully depressing the key and allowing it to repeat.

2.2.5 Test Limits

This function enables the user to compare an incoming waveform with pre-defined test limits.

The test is carried out on the selected trace over that part of the trace between the time datum and the cursor.

The test limits consist of an upper and a lower limit which are displayed as an alternating sequence of data points. During testing the test limits are displayed in the Reference 1 trace.

Test limits can be derived from an incoming signal or a waveform loaded via the IEEE/RS423 interface. The trace can be positioned, using the 'POSITION' function of the 260, to define the upper or lower limit. The limits have separate keys, 'SAVE UPPER LIMIT' and 'SAVE LOWER LIMIT' which save the selected trace as the corresponding limit when pressed.

When both limits are set the test limits are shown as a bright band on the screen.

The test limits will be held in memory until either the 1600 is switched off or the Reference 1 trace is used to display another waveform.

NOTE:- To avoid changing the input channel position on the 1600 use the 260 'POSITION' function to position a limit waveform.

When both limits are set press the 'TEST LIMIT' key. The message

PRESS AGAIN TO HALT ON FAIL

will appear on the screen. If the 'TEST LIMIT' key is pressed again while this message is displayed, the 1600 will capture waveforms until the signal on the selected trace deviates outside the test limits. When this occurs the test limit process will stop and the last trace acquired will be held on the screen.

If AUTOPLOT has been selected on the 1600 any failed trace will be plotted and then the 1600 will be re-armed and will continue testing.

If the 'TEST LIMIT' key is not pressed again, the 1600 will continuously test the selected trace and display the message

LIMITS TEST: PASS

If the signal deviated outside the test limits it will display the message

LIMITS TEST: FAIL

but the 1600 will continue to test traces. When the trace returns inside the test limits the display will again show

LIMITS TEST: PASS

In this mode the test limits process can be aborted at any time by pressing any keypad key.

Note:- While testing a trace triggers detected by the 1600 do not result in a capture and therefore not all incoming signals can be tested.

2.2.6 Set Average

Pressing the 'SET AVERAGE' key will display the current averaging factor selected: Further presses will step through and display the selections available for averaging. The selections available are: No Averaging, 2, 4, 8, 16, 32, 64, 128, 256, 512 and 1024 traces.

Pressing 'CAPTURE' initiates the averaging process which will be continuous or single shot depending on whether continuous or single shot is selected on the 1600 front panel.

In continuous capture a running average will be performed using the weighting factor selected. If a single shot capture is selected from the waveform processor, the number of triggered acquisitions is dependent upon the number of averages selected.

Note: In single shot averaging the first acquisition is displayed then the preset number of acquisitions are

made at high speed and then resulting averaged waveform is displayed.

Either form of averaging can be stopped by pressing 'ABORT'.

2.2.7 Set Envelope

Pressing the 'SET ENVELOPE' key will display the current enveloping factor selected; further processes will step through the available selections for enveloping and display these settings on the screen. The selections available are: No Enveloping, 2, 4, 8, 16, 32, 64, 128, 256 traces and Continuous Enveloping.

Pressing 'CAPTURE' initiates the enveloping process, the number of traces acquired depends upon the enveloping factor.

During enveloping the maximum and minimum excursions of the acquired traces are accumulated and displayed as a bright band. The Reference 1 trace is used to display the envelope waveform.

Enveloping can be stopped by pressing 'ABORT'.

NOTE:- Averaging and enveloping are mutually exclusive. Using 'SET AVERAGE' will cancel any existing enveloping factor and vice-versa.

2.2.8 Wait

'WAIT' prevents the waveform processor from performing any further functions until the 'NEXT' key is pressed. This function is most useful for pausing averaged or enveloped captures. If the 'WAIT' key is pressed while such an acquisition is taking place the capture will be suspended and the message

PRESS NEXT TO CONTINUE

displayed. Pressing 'NEXT' will continue the acquisition.

'WAIT' can also be used as part of a programmed sequence to halt execution until 'NEXT' is pressed.

2.3 Post-storage Functions

Topics: arithmetic operations on waveforms
filtering
Fourier transforms and frequency measurements
integration
invert
magnification and attenuation of waveforms
positioning waveforms
restoring post storage functions

Keys: DEC
FFT
FFT MENU
FILTER
INC
INTEGRATE
INVERT
MATH
MATH MENU
POSITION
RESTORE
Y MAG

The following functions will only operate once a trace has been captured or is held. For automatic operation use 'CAPTURE AND REPEAT'. The function is performed on the trace selected by the cursor. To move the cursor to another trace use the 'SELECT TRACE' key.

2.3.1 Y Mag

Selecting 'YMAG' allocates the 'INC' (Increment) and 'DEC' (Decrement) keys to magnify or reduce the waveform identified by the cursor. The range is from x0.062 to x4.0. The magnification value is indicated on the display for a limited time after selection. After magnification is applied all voltage measurements on the magnified trace will be displayed in division units.

2.3.2 Inc

The 'INC' key will increase the current magnification or increment the TV line number. The button has two positions and if held in the first the increments will be applied slowly; with the button pushed fully down the increments will be fast.

2.3.3 Dec

The 'DEC' key will decrease the current magnification or decrement the TV line number. The button has two positions and if held in the first the decrements will be applied slowly; with the button pushed fully down the decrements will be fast.

2.3.4 Filter

Pressing 'FILTER' for the first time will display the current filter setting. Subsequent presses will step through the filter stages, returning to the "NO FILTERING" position. There are 6 stages of filter for each timebase range.

The filter is a single pole low pass filter, where the alpha-numeric display indicates the 3dB point.

$$\text{Cut-off frequency} = \frac{15.92}{T} \ln\left(1 + \frac{1}{2^m}\right)$$

T = timebase
m = filter step
ln = natural logarithm

2.3.5 Position

The trace identified by the cursor can be moved via the keypad after it has been stored. Pressing 'POSITION' allocates the ◄,►,▲ and ▼ position controls to shift the selected trace in X and Y. When moved in X, the trace will roll round, disappearing at one edge of the screen and reappearing at the other.

2.3.6 Invert

Pressing 'INVERT' will invert the selected trace about the voltage datum. A record of the original trace is taken and so 'RESTORE' will undo the last action of this function.

2.3.7 Integration

Pressing 'INTEGRATE' will calculate and display the integrated waveform of the selected trace.

The voltage datum is taken as zero for integration. The cursor reads out the value in Vs (Volts-seconds or similar units).

2.3.8 Fast Fourier Transform

The Waveform Processor can perform a Fourier transform on any trace captured by the 1600. Pressing 'FFT MENU' ('F' followed by 'FFT') displays the options associated with the FFT.

WINDOW: Rectangular Hanning 1
POINTS: 1024 512 256 CURSOR 2
RESULT TO:
CH1 CH2 CH3 CH4 REF1 REF2 3
HORIZ SCALE: Linear Log 4
VERT SCALE: Linear Log 5
Hz MEASUREMENT: Harmonic Rel 6

‹‹ FOURIER TRANSFORM MENU ››

Fig 2.3.1. Fourier Transform options.

The options available using this menu are as follows:-

The number of points analysed by the FFT is selected from this menu. With 1024, 512 or 256 points the FFT will use every point, every 2nd point and every 4th point of the source trace respectively. The FFT will calculate the frequency spectrum faster when using the smaller number of points. However, it should be noted that using 512 or 256 points will reduce the frequency resolution and the maximum frequency detectable in the result.

The following formulae give the frequency range for any number of points analysed.

$$\text{minimum frequency displayed} = \frac{1}{\text{time duration of trace}}$$

$$\text{maximum frequency displayed} = \frac{\text{Number of points analysed}}{2 \times \text{time duration of trace}}$$

Alternatively, if CURSOR is selected then only those points between the time datum and the cursor will be used in the transform. This is useful for selecting a part of the waveform to be analysed. NOTE:- If the number of points bounded by these cursors is not exactly 1024, 512 or 256 points then the trace will be padded out symmetrically to the next highest of these values. This padding is done by adding additional points of the same value as those at the cursors.

One of two windowing functions is applied to the waveform prior to perform the FFT. The RECTANGULAR window should be used when analysing transients or bursts of frequency. The HANNING window should be used with continuous waveforms as it reduces the effects of discontinuity at the edges of the trace.

The frequency spectrum produced by the FFT can be chosen to give linear or logarithmic scaling in the frequency and/or voltage axes.

The final option on the FFT menu selects the format of the cursor measurements on a frequency spectrum produced by an FFT. The Waveform Processor will always display the frequency and voltage at the cursor when a frequency spectrum is selected. In addition, one of two other measurements can be shown. If REL (relative) is selected the difference in frequency between the time datum and the cursor is displayed.

CH1: 4.5v 250HzRel 500Hz

Alternatively, if HARMONIC is selected the ratio of frequencies at the time datum and the cursor is

calculated. Clearly this mode is used for measuring harmonic relationships between peaks in the frequency spectrum.

CH1: 4.5v x2 500Hz

The Fourier transform is performed on the trace selected by the cursor by pressing the 'FFT' key. The resulting frequency spectrum is displayed on the trace selected from CH1, CH2, CH3, CH4, REF1 and REF2.

The waveform processor cannot perform an FFT on traces with expansions greater than x10. Attempting to do so will generate the message

FFT ABORTED: X MAG x10 MAX

Note: Cursor movement on the frequency spectrum produced by the FFT differs from that on normal waveforms. The cursor can only be positioned at frequencies that can be resolved by the FFT process. This ensures that only results produced by the FFT can be measured. Since the resolution depends upon the number of points considered the cursor will move in larger steps on a frequency spectrum produced by a 256 point FFT than on a 512 point FFT.

Note: The DC component of the original waveform is not given in the resulting frequency spectrum.

2.3.9 Trace Arithmetic

Trace arithmetic performed using the waveform processor is a more generalised version of that available via the 1600 Special Functions Menu. It has a scaling factor (x1, x.5, x.2 and x.1) that is applied after a multiplication has been performed. Trace arithmetic can be performed as part of the programmable sequence.

Pressing the 'MATH MENU' key ('F' followed by 'MATH') displays the trace arithmetic menu.

CH1 CH2 CH3 CH4 REF1 REF2 1

Add Subtract Multiply 2

CH1 CH2 CH3 CH4 REF1 REF2 3

RESULT TO:

CH1 CH2 CH3 CH4 REF1 REF2 4

SCALE: x1 x.5 x.2 x.1 5

« TRACE ARITHETIC MENU «

Fig 2.3.2. Trace Arithmetic setup.

This menu is used to select the source traces, the destination trace and the arithmetic operation to be performed. Selections are made in the same manner as any of the menus available on the 1600, by using the numeric keys or the datum movement keys.

The arithmetic operation is actioned by a single press of the 'MATH' key when in trace mode. Trace arithmetic performed in this way has the advantage of being easily repeatable and, as it is regarded as a post-storage function, it can be used in combination with 'CAPTURE AND REPEAT'.

2.3.10 Restore

'RESTORE' cancels the last post storage function on the currently selected trace. The previous trace is re-displayed. 'RESTORE' cannot undo functions prior to the last post storage function. Neither can it restore a trace if another trace has been selected or if the cursoirs are no longer displayed.

2.4 Waveform Measurements

Topics: Area
dB and percentage measurement
frequency
maximum and minimum measurement
measurement printout
overshoot
peak to peak voltage
plotting
preshoot
pulse width
rise and fall time
RMS

Keys: AREA
dB/%
FREQUENCY
MAX/MIN
OVERSHOOT
PK/PK
PLOT
PRINT ON/OFF
PULSE WIDTH
RISE TIME
RMS
SET REF
SET %

For the functions in this section the waveform processor will continuously calculate the results until either another waveform measurement is selected or 'INITIALISE' is pressed. The measurements are made on the trace selected by the cursors, between the time datum and the cursor. If the cursors are not displayed then measurements will be made on the last trace selected across the entire trace, and the voltage datum is assumed to be at the centre of the screen.

2.4.1 Rise Time and Rise Time Percentage

The cursor and time datum should be positioned at the 0% and 100% points of the waveform. The waveform processor calculates the rise/fall time either between the 10 and 90% points of the waveform or between percentage points selected by the user. The first press of 'RISETIME' will display the current setting, ie. either 10/90% or the user selected values. Further presses will alternate between these two selections.

The user selected percentages are entered by pressing 'SET %' ('F' followed by 'RISETIME'). The message

ENTER RISE/FALL%: 00/00%

is displayed. The two percentages are entered by pressing the appropriate numeric keys on the keypad or front panel of the 1600. For example pressing '1','5','8' and '5' gives

ENTER RISE/FALL%: 15/85%

After the two numbers have been entered the rise time measurement is automatically selected using these percentages.

2.4.2 Preshoot and Overshoot

The cursor and time datum should be placed at the 0% and 100% points of the waveform. The waveform processor calculates the overshoot as a percentage of the voltage difference between the 0% and 100% points.

Fig 2.4.1. Pulse Width Measurement.

2.4.3 Pulse Width

The waveform processor measures the time between the 50% points of a pulse. The time datum and cursor must be located on either side of the pulse to be measured. Positive or negative pulses can be measured in this way.

The first pulse encountered is measured and if the leading edge of the pulse is noisy, the waveform processor could read the value of the noise part of the pulse.

2.4.4 Frequency

The waveform processor will display the frequency, period and duty cycle of the selected trace. The voltage datum sets the zero crossing voltage. If the voltage datum is outside the waveform excursion, the mean of the trace between the time datum and the cursor is calculated and is used to define the zero level. If the cursor is not displayed, the results are calculated for the entire waveform taking the centre of the screen as the position of the voltage datum.

The cursor and time datum must enclose at least three zero crossings (One complete cycle) or a warning 'TRACE INVALID' will be displayed.

The period is the inverse of the frequency calculated above.
The duty cycle is the ratio of mark or space at the time datum to whole pulse period expressed as a percentage. If the time datum is on a space, the ratio of mark to period is displayed.

2.4.5 Max/Min

The display reads the maximum positive point and minimum negative point of the waveform between the cursor and the time datum. Voltages are measured with respect to voltage datum. If no cursors are displayed the Max/Min points of the entire trace are calculated with respect to the centre of the screen.

2.4.6 Pk/Pk

The display reads the peak to peak voltage difference between the most positive and negative points of the trace between the cursor and time datum. If no cursors are displayed the Pk/Pk value of the entire trace is calculated.

2.4.7 RMS

The display reads two values:
RMS - the RMS voltage with respect to the voltage datum. AC - the RMS voltage with respect to the mean of trace. If no cursors are displayed the RMS voltage of the entire trace is calculated with respect to the centre of the screen.

2.4.8 Area

Calculates the area under the curve bounded by the trace, cursor, voltage datum and time datum. If no cursors are displayed, the area will be that bounded by the left and right edges of the screen and the centre of the screen.

The waveform processor assumes that if the trace goes below the horizontal datum, as in the example shown in Fig. 1, the area is negative.

Area B is added algebraically to Area A and the result displayed.

If Area B is greater than Area A the result is a negative area. The result is in Vs (Volts-seconds) or similar units.

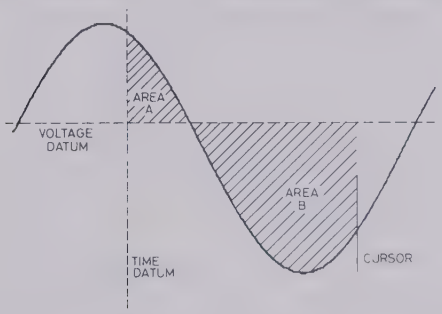


Fig 2.4.2. Definition of Area under curve.

2.4.9 dB and Percentage Measurement

The waveform processor can measure voltage ratios in dB, dBV (dB wrt 1V) and as a percentage. The modes are labelled as follows:

STANDARD UNITS, VOLTS, SECONDS
LOG SCALE, dB wrt REF
LOG SCALE, dB wrt 1V
PERCENTAGE SCALE wrt REF

The 'dB/%' key is used to select which mode is used. The first press will display the current setting, repeated presses cycle through the modes available.

The 'SET REF' key (F followed by 'dB/%') is used to set the reference voltage (Vref) used in calculating dB and percentage results. The first press will display the current value of the reference voltage. A second press of F followed by 'dB/%' will set the reference voltage to the current voltage difference between the cursor and the voltage datum. Attempting to set a reference voltage of 0V will result in the error message

CANNOT SET REFERENCE, 0V

Measurements are calculated according to the following formulae:-

$$dB = 20 \times \log(\frac{V}{Vref}) \qquad dBV = 20 \times \log(V)$$

$$\text{percentage} = 100 \times \frac{V}{Vref}$$

2.4.10 Print

If the 1600 is fitted with an internal plotter the waveform processor can produce a printed copy of the alphanumeric measurement line displayed at the bottom of the screen along with the current time and date. For example

CH3: 1.56 mV 3.92mS 16:45:10
03/01/88

This measurement printout facility operates in two modes.
Pressing 'PRINT ON' once will list the current measurement line along with the current time and date.

In the second mode the printing process is automatic. If 'PRINT ON' is pressed twice in succession the measurement line will be printed every time the measurement type is changed. For example, if the current measurement is RMS when 'PRINT ON' is pressed twice, the current RMS measurement will be printed. If 'MAX/MIN' is then selected on the keypad the maximum and minimum values of the waveform are printed. Note that only the first measurement made by the waveform processor is printed when the measurement type is changed.

In addition any 'CAPTURE' performed while the measurement printout is enabled will be printed by the waveform processor.

Pressing 'PRINT OFF' turns off this continuous printout mode.
Consult your 1600 operation manual for details of how to select the internal plotter.

2.4.11 Plot

Plots the currently displayed traces or menu on the selected plotter.

Consult your 1600 operation manual for details of how to select the internal plotter.

2.5 Option Functions Menu

Topics: auto capture and save
reference memory
clearing
recall from
saving to
selection
size

SAVE CH1 TO MEMORY 18 1

(Trace selected by cursor)

RECALL MEMORY 18 TO REF 1 2

RECALL MEMORY 18 TO REF 2 3

SELECTED 17 02/15/88 CH2 ▲

MEMORY: 18 02/15/88 CH3

19 02/15/88 CH4 ▼

AUTO CAPTURE & SAVE: Off On 6

MEMORY SIZE: 50x1K 5x10K 7

CLEAR MEMORY 18 8

‹‹ REFERENCE WAVEFORMS ››

Fig 2.5.1. Reference Memory options

This menu allows the user to access the reference memories in the Waveform Processor Interface module.

2.5.1 Save Trace to Memory

To save the currently selected trace to the reference memory shown, press button 1. The word 'saving' will appear briefly on the menu display. Upon completion the selected memory display line will increment, as will all other reference memory indicators on the menu.

2.5.2 Recall from Reference Memories

Recall Memory to Ref 1 To recall a previously stored reference memory to reference trace 1 press

button 2. The word 'recalling' will appear briefly on the menu display. Upon completion the selected memory display line will increment, as will all other reference memory indicators on the menu.

When recalling a 10K reference memory, the current settings of × magnification and × shift are taken into account when transfering the data to the display.

Recall memory to Ref 2 To recall a previously stored reference memory to reference trace 2 press button 3. The word 'recalling' will appear briefly on the menu display. Upon completion the selected memory display line will increment, as will all other reference memory indicators on the menu.
When recalling a 10K reference memory, the current setting of X mag and X shift are taken into account when transfering the data to the display.

2.5.3 Selected Memory

This display line shows the current selected reference memory that will be used by all other functions on the menu screen. The next available sections are also shown above and below the current line. The selection memory can be altered by moving in either direction by pressing button 4 to decrement or button 5 to increment.

2.5.4 Auto Capture & Save

Pressing button 6 will toggle this menu function to ON. The current state is shown in reverse video flashing. When ON, the function is started by a second press of button 6 while the message 'PRESS AGAIN TO START' is displayed. This causes the following sequence of events to occur, starting at the currently selected reference memory number:

a) Instrument armed.
b) Wait till stored.
c) Transfer selected trace to current reference memory.
d) Increment the selected memory number.

The above sequence is repeated until the upper limit of the available reference memories is used (i.e. 5 or 50). The function is cancelled by operating a menu selection.

2.5.5 Memory Size

This allows the user to alternate between the two types of memory configuration either 50 × 1K or 5 × 10K.

Press button 7 will briefly display the message "PRESS AGAIN", if button 7 is pressed again the configuration will change from current to the alternative selection. The repeated push for operation is a safeguard against accidental usage.

2.5.6 Clear Memory

This allows the user to clear the currently selected memory. Pressing button 8 will briefly display the message "PRESS AGAIN", if button 8 is pressed again the currently selected memory will be cleared and the date stamp on the selected memory display line will show ‹UNUSED›. The selected memory number will not update. The repeated push for operation is a safeguard against accidental operation.

2.5.7 Save One / Save All

These functions allow selected traces to be transfered to the non-volatile reference memories while traces are displayed. Pressing 'SAVE ONE' will transfer the trace selected by the cursor to the current reference memory and increment the reference memory number. Similarly, pressing 'SAVE ALL' will save all displayed traces to consecutive reference memories.

3. PROGRAMMABLE SEQUENCES

Topics: adding and deleting sequence steps
continuous and one-off execution
deleting the programmable sequence
displaying multiple measurements
entering and editing programmable sequences
executing and single stepping the programmable sequence
listing the programmable sequence
measurement scrolling
suspending a sequence
valid operations in programmable sequences

Keys: ABORT
CAPTURE
CAPTURE AND REPEAT
DELETE
EDIT
EXECUTE
EXIT
FFT MENU
INITIALISE
LEARN
MATH MENU
NEXT
PLOT
PREV
PRINT
S/STEP
WAIT

The waveform processor can be programmed to perform a sequence of up to 24 acquisition, post-storage and measurement functions. This sequence can then be executed from the keypad by a single key press.

There are two methods of entering and editing a programmable sequence, either while traces are being manipulated or via a menu where waveform processor functions can be added to or deleted from the sequence.

For example, consider the simple problem of comparing the FFT of a waveform with the FFT of the same waveform after it has been filtered. This can be performed in the following manner using standard waveform processor functions.

1) capture the waveform
2) select cursors on the waveform
3) select the destination of the FFT to be a different trace
4) perform the FFT
5) restore the original waveform

6) Filter waveform
7) select the current trace as the FFT destination
8) perform the FFT

Because the two FFT results appear on top of each other it is best to separate them using POSITION.

9) select position and shift the current trace down
10) select the first FFT result
11) select position and shift the current trace up
12) plot the result

Once the programmable sequence has been entered the sequence can be executed with the press of a single key.

3.1 Entering a Sequence Using LEARN

In 'learn mode' the waveform processor will remember waveform processor functions as they are executed. When 'LEARN' (F EDIT) is pressed the message

PRESS LEARN AGAIN TO DELETE
SEQUENCE AND START LEARNING

is displayed. If 'LEARN' is pressed again while this message is displayed the waveform processor will enter 'Learn mode'.

NOTE:- Entering learn mode will delete any previous sequence present in the waveform processor. The second press of 'LEARN' is a safeguard against accidental erasure of a sequence.

Facilities are provided for listing the sequence on an internal plotter (see section 3.6.1 Listing a Sequence) and for saving the sequence via an IEEE/RS423 interface (see SEQU in section 4.3). PLOT can also be used with an internal or external plotter to plot the screen contents when editing the sequence.

While in learn mode the screen will show

LEARN: ENTER SEQUENCE

A sequence of up to 24 functions can now be performed before the programmable sequence store is full. As with normal keypad operation the corresponding functions are performed as the keys are pressed.

NOTE:- Although only 24 functions can be entered, each function may consist of a number of individual key presses. For example, selecting a Y magnification of x4.00 can take up to 60 presses of the "INC" key. Learn mode will remember only the final state of each function, ie. that a x4.00 magnification was reached.

Once in learn mode the sequence outlined above is entered by invoking the functions corresponding to each step.

1) press 'CAPTURE'.
2) press 'SELECT TRACE' until the correct trace is selected.
3) press 'FFT MENU' then use the soft keys or datum keys to change the FFT destination.
   exit using the MENU/TRACE or '0' keys.
4) press 'FFT'.
5) press 'RESTORE'.
6) press 'FILTER' until the required filtering is achieved.
7) press 'FFT MENU' then use the soft keys or datum keys to change the FFT destination.
   exit using the MENU/TRACE or '0' keys.
8) press 'FFT'.
9) press 'POSITION' then use the ▼ key to shift the trace down by 2 divisions.
10) press 'SELECT TRACE' until the first FFT trace is selected.
11) press 'POSITION' then use the ▲ key to shift the trace up by 2 divisions.
12) press 'PLOT'.

To indicate that the sequence is complete press the 'EXIT' key. The message

LEARN: SEQUENCE COMPLETE

message will appear to indicate that the waveform processor is no longer in Learn mode. The sequence is stored and executed as it is entered and will remain in the waveform processor until it is deleted or is replaced with a new sequence. As the programmable sequence memory is battery backed the sequence will be retained even if the waveform processor interface is disconnected from the 1600.

Learn mode can be terminated in a number of ways.

1) pressing the 'EXIT' key as described above.
2) pressing the 'EXECUTE' key terminates the sequence and runs it immediately.
3) pressing the 'S/STEP' key terminates the sequence and starts the single step process.
4) pressing the 'EDIT' key terminates the sequence and enters edit mode.
5) pressing 'LEARN' again terminates the sequence then, once again, gives the option of clearing and entering a new sequence.

If the limit of 24 functions is reached while learning the message

LEARN: SEQUENCE FULL

appears on the display. Any further key presses are executed but are not added to the sequence.

NOTE:- There are certain function keys that cannot be included in a programmable sequence. These include all the keys in the 'program' section of the keypad and the 'CAPTURE AND REPEAT' key. The effect of pressing one of these keys when in learn mode is as follows:-
Pressing 'CAPTURE AND REPEAT' will display the message

KEY NOT ALLOWED IN SEQUENCE

for a short time. Pressing 'CAPTURE AND REPEAT' does NOT terminate learn mode.
Pressing 'DELETE', 'PREVIOUS' and 'NEXT' will display

KEY ONLY AVAILABLE IN EDIT MODE

as these functions are used only when editing or single stepping a sequence.

Again the waveform processor will remain in learn mode if these keys are pressed.
Pressing 'LEARN', 'EDIT', 'S/STEP' or 'EXECUTE' will terminate learn mode and then start the corresponding programmable sequence function.

NOTE:- When entering a sequence front panel keys can be used but are not included in the sequence.

NOTE:- 'INITIALISE' will restore the waveform processor to its default state, but it will not erase a programmable sequence.

3.2 Executing a Sequence

Once a sequence has been entered it can be executed at any time by pressing the 'EXECUTE' key when traces are displayed on the screen.

If the 1600 is in continuous acquisition mode when 'EXECUTE' is pressed the waveform processor will repeatedly acquire a trace and execute the sequence until 'ABORT' is pressed.

If the 1600 is in stored mode when 'EXECUTE' is pressed the sequence will be executed only once. Note that, unlike the continuous execution described above, no trace is acquired prior to executing the sequence and the sequence will operate on the traces displayed. If it is necessary to acquire new traces before executing the sequence, either, press 'CAPTURE' before pressing 'EXECUTE', or include 'CAPTURE' as the first step of the sequence.

NOTE:- Errors that occur during execution DO NOT stop the sequence from running. For example, attempting to perform a filter operation without first selecting a trace produces the message

NO TRACE SELECTED

However this will not stop the sequence from executing. The one exception to this rule is if an attempt is made to move the cursors to a trace that is not displayed (see section 3.7).

3.3 Executing a Sequence in Single Step Mode

It is also possible to step through the sequence using 'S/STEP' and 'NEXT' key. In single step mode a description of each function is displayed as it is executed. Once the function is complete execution of the sequence is suspended and the message

PRESS NEXT TO CONTINUE

is displayed until 'NEXT' is pressed.

While in single step mode it is not possible to step backwards. Neither is it possible to insert new steps or delete existing steps from the sequence. Changes such as these can be made only in edit mode. However a limited amount of editing can be performed on the current step. Details on when this applies are given in section 3.4.

To continue executing the sequence from the current step at the normal speed press 'EXECUTE'. The waveform processor will no longer wait for 'NEXT' to be pressed between sequence steps.

To abort the single step process press 'ABORT.

When the execution of a sequence is complete (either as a result of pressing 'EXECUTE' or having single stepped through the entire sequence) the message

EXECUTION COMPLETE

appears on the screen for a short time.

3.4 Editing While Single Stepping

A certain amount of editing can be performed while single stepping. If the current step contains parameters, such as the cursor position in the following line

7_CURSOR: 3.57 xDIV

The left and right cursor keys can be used to adjust the cursor position to the required value.

7_CURSOR: 6.29 xDIV

This facility is used for making alterations to cursors positions, trace selection, y-magnifications, TV lines, filtering, averaging and enveloping factors, cursor modes and scaling.

3.5 Capture and Re-Execute

Execution and single stepping are regarded as a post-storage functions. Therefore, if the last post-storage function was 'EXECUTE' and 'CAPTURE AND REPEAT' is pressed, then the waveform processor will perform an acquisition and re-execute the current sequence. Similarly, if the last function was 'S/STEP' and 'CAPTURE AND REPEAT' is pressed, a new trace is acquired and the sequence is re-executed in single step mode.

3.6 Editing a Sequence

While it is possible to enter sequences using only learn mode it is also possible to modify the current sequence. 'Edit mode' allows insertion and deletion of waveform processor functions, modification of existing sequence steps, control over the measurement scroll option and the ability to produce a listing of the sequence.

When the 'EDIT' key is pressed the screen is cleared of traces and up to 14 lines of the current sequence are displayed. Also displayed is the message

Press LEARN to clear sequence

If LEARN is pressed at this point all steps in the current sequence are deleted and a new sequence can be entered. The ability to clear the current sequence is only available before any other key is pressed while editing.

Once a key is pressed the sequence clear option is replaced with a menu option for enabling the measurement scrolling option.

measurement scroll OFF ON . . 1

Measurement scrolling allows several waveform measurements to be displayed on the screen at one time (see section 3.9). It is toggled between ON and OFF at any time using the '1' key.

While editing each function is listed along with a number giving its position in the sequence.

1_CAPTURE
2 INVERT
3 INTEGRATE
4 MAX/MIN

The function currently being edited is indicated by the ' ' symbol to the right of the step number. Subsequent or previous steps can be reached using the 'NEXT' and 'PREVIOUS' keys. For example, pressing 'NEXT' twice would produce the following display.

1 CAPTURE
2 INVERT
3_INTEGRATE
4 MAX/MIN

The 'DELETE' key is used to remove a step from the sequence. Pressing 'DELETE' produces

1 CAPTURE
2 INVERT
3_MAX/MIN

A new function can be inserted after the current function by pressing the corresponding key. Pressing 'FFT' produces

1 CAPTURE
2 INVERT
3 MAX/MIN
4_FFT

If no sequence is present when in edit mode because the user deleted all the steps in the sequence, the message

NEW SEQUENCE

appears on the screen.

There are a number of ways of leaving edit mode. Pressing '0' on the keypad returns to trace mode. Pressing 'EXECUTE' returns to trace display and immediately begins executing the current sequence. Similarly, pressing 'S/STEP' returns to trace mode and immediately begins single stepping the current sequence. Pressing 'EXIT' will also return to trace display but will also give the option of listing the sequence on an internal plotter if one is fitted (see section 3.6.1).

3.6.1 Listing a Sequence

If an internal plotter is fitted and is selected, pressing 'EXIT' displays the message

Press PRINT ON to list and exit

Pressing 'PRINT ON' will list the sequence on the internal plotter. If any other key is pressed no action is taken and traces are re-displayed. For details on how to select an internal plotter consult the 1600 operators manual.

Alternatively pressing 'PLOT' while editing will produce a copy of the programmable sequence on an internal or external plotter. However this will only list the steps displayed.

3.7 Entering a Sequence in Edit Mode

The use of edit mode is not confined to modifying sequences entered using LEARN. Sequences can be created in edit mode as an alternative to using LEARN. Entering sequences this way is the ability to insert and delete steps and modify existing ones at will. However it is not possible to see the effect the sequence has on traces until it is executed.

To create a step in edit mode press the same sequence of keys that would be needed to perform the function under normal waveform processor operation. In many cases waveform processor functions are selected with a single key press, eg. 'CAPTURE', 'AREA', 'OVERSHOOT', 'PLOT' etc. These can be entered into a sequence simply by pressing the corresponding key. Repeatedly pressing such a key will result in multiple steps with the same function. For example, pressing 'CAPTURE' three times starting with an empty sequence will give.

```
1 CAPTURE
2 CAPTURE
3_CAPTURE
```

Clearly, when executed, this sequence will perform three acquisitions.

There are several waveform processor functions that have options or parameters associated with them, for example. 'SET AVERAGE' (OFF, 2, 4, ...), 'FILTER' (OFF, 1, 2, 3, 4, 5, 6), 'CURSOR MODE' (V wrt voltage datum, V wrt voltage at time datum, T to last crossing point) etc. As with normal keypad operation, repeated presses of the key corresponding to these functions will cycle through the options available. For example, pressing 'SET AVERAGE' for the first time will give

```
4AVERAGING OFF
```

a further presses will produce

```
4_AVERAGE 2 TRACES
4_AVERAGE 4 TRACES
4_AVERAGE 8 TRACES
```

up to

```
4_AVERAGE 1024 TRACES
```

Note that only one programmable sequence step is produced, no matter how many times 'SET AVERAGE' is pressed. Only the average factor associated with 'SET AVERAGE' is changed.

As a further example, 'FILTER' works in a similar way to 'SET AVERAGE' with successive presses producing

5_FILTERING OFF
5_FILTER 1
5_FILTER 2
5_FILTER 3

up to 5_FILTER 6

YMAG uses a combination of the 'YMAG' key and the 'INC' and 'DEC' keys to produce a program step. Pressing 'YMAG' will produce the following step in the sequence

6_YMAG × 1.000

The 'INC' and 'DEC' keys can now be used to change the magnification that will be applied. For example, repeatedly pressing 'INC' produces

6_YMAG × 1.062
6_YMAG × 1.125
6_YMAG × 1.187
6_YMAG × 1.250

up to

6_YMAG × 4.000

Note that it is necessary to press 'YMAG' before using the 'INC' and 'DEC' keys in order to indicate that they are being used to change magnification as opposed to changing TV line. Failure to do so will produce the message

PRESS YMAG OR TVLINE FIRST

Pressing 'TV LINE' allows both the TV line and TV standard to be selected. Repeated presses of 'TV LINE' will cycle through the NTSC, PAL and SECAM settings

8_TV LINE: NTSC LINE 1 FRAME 1
8_TV LINE: PAL LINE 1
8_TV LINE: SECAM LINE 1

while pressing the 'INC' and 'DEC' keys will alter the TV line appropriately.

8_TV LINE: SECAM LINE 2
8_TV LINE: SECAM LINE 3
8_TV LINE: SECAM LINE 4

For more details on the range of TV lines selectable for

each TV standard, see the Acquisition Functions section of this manual (section 2.2).

The programmable sequence supports movement of the CURSOR, the TIME and VOLTAGE DATUM and the traces. Pressing either of the CURSOR movement keys will produce a line of the form

9_CURSOR: 3.57 xDIV

The left and right cursor keys are then used to select the required position, eg.

9_CURSOR: 6.29 xDIV

When this line is executed the cursor will be placed 6.29 divisions from the start of the trace.

Similarly, pressing DATUM will produce a line of the form

10_DATUM: 4.0xDIV 2.70yDIV

which can then be adjusted using the ◄, ►, ▲ and ▼ keys to give the required values. Pressing DATUM again will switch between this format and

10_DATUM: TO CURSOR POSITION

which, when executed, will act in an identical fashion to pressing DATUM twice when traces are displayed, ie. it will set the voltage datum and time datum to the current cursor position.

Pressing POSITION gives a similar line to pressing DATUM.

10_POSITION: 7.5xDIV -1.5yDIV

The X and Y shift values can again be changed using the ◄, ►, ▲ and ▼ keys. When the sequence is executed this line will cause the trace to shift 7.5 divisions horizontally and -1.5 divisions vertically.

'SELECT TRACE' can be used in a sequence to move the cursors to a particular trace or to turn the cursors off. Pressing 'SELECT TRACE' will cycle through

11_CURSORS TO CH1
11_CURSORS TO CH2
11_CURSORS TO CH3
11_CURSORS TO CH4
11_CURSORS TO REF1
11_CURSORS TO REF2
11_CURSORS OFF

NOTE:- If, while executing a sequence, an attempt is made to move the cursors to a trace that is not displayed,

the sequence is aborted with the message

CHANNEL NOT ON

This is necessary because it is impossible to predict which traces will be ON when the sequence is executed. This is the only time execution of a programmable sequence is aborted.

3.8 FFT and MATH Steps in a Sequence

To enter an FFT or MATH operation into a sequence press the corresponding key.

For each FFT or MATH step included in a sequence there is a copy of the FFT MENU or MATH MENU. These menus can be edited by pressing F FFT or F MATH when an FFT or MATH operation is the current step. The corresponding menu will be displayed and can be modified to give the required function. Pressing '0' or '9' will return to the editing menu. Each FFT/MATH step in the sequence can have a different setup and therefore a different action.

For example the setup for

12_MATH may be CH1 + CH2 to CH3

and for

18_MATH REF1 * CH3 to REF2

When executing FFT or MATH steps the waveform processor will use the settings placed in the menu when entering each step.

3.9 Measurement Scrolling

Because of the speed at which a programmable sequence is executed it can be difficult to examine the results as they are displayed on the screen. This effect is most obvious when a sequence contains two consecutive measurement functions.

1 CAPTURE
2 FREQUENCY
3 MAX/MIN
4 PK/PK
5 VOLTS, TIME MODE

Having executed step 2 the frequency measurements will be displayed but are immediately replaced by the MAX/MIN measurements. Using scroll allows successive measurements to be retained on the display. 'Measurement scrolling' can be turned on and off by

pressing '1' while editing the sequence. For example, having selected scrolling, if the sequence above is executed the following display would be produced.

1V OFF OFF OFF 100μs

CH1: 2.50kHZ 0.4000ms 05.2%
CH1: MAX 4.5V MIN-1.4V
CH1: PK-PK 3.26V

CH1:-0.14V 50μs

Up to eight lines can be displayed before the first measurement is scrolled off the top of the list.

3.10 Wait

In addition the WAIT function can be included in a sequence to suspend execution at any point and freeze the display for examination. At this point the message

PRESS NEXT TO CONTINUE

will be displayed on the screen and will remain until 'NEXT' is pressed. 'WAIT' can also be used in a sequence to suspend execution while manual changes need to be made to the 1600 front panel.

4. IEEE/RS423 CONTROL

Topics: control of the 260 waveform processor
via an IEEE/RS423 interface
details of functions

The type 260 Waveform Processor adds a range of additional commands to the IEEE/RS423 command set of the 1600.

4.1 IEEE/RS423 COMMAND SUMMARY

Key to the command summary:
A Assertive
I Interrogative
D Direct action assertive

Command	Parameter	Function	Type
ACRMS		RMS value about mean of waveform	I
ADEST	trace	Select destination of trace arith	A,I
AOPND	trace	Select second source for trace arith	A,I
AREA		Area under trace	I
AROP	SUM SUB MULT	Select trace arithmetic operation	A,I
ASCALE	1,2,5,10	Select scaling after trace multiply	A,I
ASRC	trace	Select first source for trace arith	A,I
CALC		Perform trace arithmetic	D
CAPTURE		Arm the 1600 to acquire traces	D
CMODE	NORMAL RELDAT RELTRC	Select cursor measurement mode	A,I
CSCALE	NORMAL DB DBV PER	Select cursor scaling	A,I
DUTY		Duty cycle about voltage datum	I
FFT		Perform a Fourier Transform	D
FFTHSC	LIN LOG	Select FFT horizontal scaling	A,I
FFTMEAS	HARM REL	Select FFT freq. measurement	A,I
FFTPTS	1024 512 256 128 CURSOR	FFT points sampled	A,I
FFTTRC	trace	FFT destination trace	A,I
FFTVSC	LIN LOG	FFT vertical scaling	A,I
FFTWIND	RECT HANN	FFT window selection	A,I
FILTER	1,2,3,4,5,6	Filter trace with one of 6 filters	D
FREQ		Frequency about voltage datum	I
HELLOWP		Waveform processor hello message	I
HPS	number	Horizontal post storage shift	A,I
INIT		Initialise keypad	D
INTG		Integrate about voltage datum	D
INVPS		Invert trace after storage	D

LIM	CONT HALT OFF	Test Limits A,I	
LIMST	PASS FAIL	Limit status	I
LOWLIM		Save lower limit	D
MAX		Maximum measured from datum	I
MEAN		Average voltage of trace	I
MIN		Minimum measured from datum	I
OVER		Overshoot percentage	I
PEAK		Peak to peak time	I
PERIOD		Period at datum level	I
PRESH		Preshoot percentage	I
PRINT	ON OFF	Enable/Disable results printout	A,I
REFM		Reference Memory transfer	A,I
REFT		Reference Trace transfer	A,I
RISE		Rise time at 10%,90% points	I
RMHS		Reference memory horizontal scaling	A,I
RMVS		Reference memory vertical scaling	A,I
RMS		RMS value measured from datum	I
RMTYPE		Reference memory type	A,I
RESTORE		Recover from last function	D
(VPS)		Vertical position post storage (see 1600 operating manual)	
RISEPER	0-100	Rise/fall variable bounds	A,I
RUNSEQ		Execute programmable sequence	D
SAVEONE		Save current trace to ref. memory	D
SAVEALL		Save all traces to ref memories	D
SEQU		Programmable sequence transfer	A,I
SETAVG	OFF,2,4,8, 16,32,64, 128,256, 512,1024	Set averaging factor	A,I
SETENV	OFF,2,4,8, 16,32,64, 128,256, CONT	Set enveloping factor	A,I
SETREF		Set dB and %age reference voltage	A,I
TVLINE		number TV line number	A,I
TVSTD	PAL NTSC SECAM	TV standard	A,I
TVMODE	ON OFF	TV mode triggering	A,I
UPLIM		Save upper limit	D
VTMODE		Select volts, time measurement	D
WIDTH		Pulse width at 50% points	I
YCAL	CAL UNCAL	Vertical calibration	I
YMAG	number	Post storage Y magnification	A,I
YSCALE	number	Vertical scaling factor	I

4.2 General

The IEEE/RS423 commands are designed to allow access to the functions of the 260 waveform processor, they operate in the same way as pressing the buttons on the keypad. All the measurement functions which return

4. IEEE/RS423 CONTROL

Topics: control of the 260 waveform processor
via an IEEE/RS423 interface
details of functions

The type 260 Waveform Processor adds a range of additional commands to the IEEE/RS423 command set of the 1600.

4.1 IEEE/RS423 COMMAND SUMMARY

Key to the command summary:
A Assertive
I Interrogative
D Direct action assertive

Command	Parameter	Function	Type
ACRMS		RMS value about mean of waveform	I
ADEST	trace	Select destination of trace arith	A,I
AOPND	trace	Select second source for trace arith	A,I
AREA		Area under trace	I
AROP	SUM SUB MULT	Select trace arithmetic operation	A,I
ASCALE	1,2,5,10	Select scaling after trace multiply	A,I
ASRC	trace	Select first source for trace arith	A,I
CALC		Perform trace arithmetic	D
CAPTURE		Arm the 1600 to acquire traces	D
CMODE	NORMAL RELDAT RELTRC	Select cursor measurement mode	A,I
CSCALE	NORMAL DB DBV PER	Select cursor scaling	A,I
DUTY		Duty cycle about voltage datum	I
FFT		Perform a Fourier Transform	D
FFTHSC	LIN LOG	Select FFT horizontal scaling	A,I
FFTMEAS	HARM REL	Select FFT freq. measurement	A,I
FFTPTS	1024 512 256 128 CURSOR	FFT points sampled	A,I
FFTTRC	trace	FFT destination trace	A,I
FFTVSC	LIN LOG	FFT vertical scaling	A,I
FFTWIND	RECT HANN	FFT window selection	A,I
FILTER	1,2,3,4,5,6	Filter trace with one of 6 filters	D
FREQ		Frequency about voltage datum	I
HELLOWP		Waveform processor hello message	I
HPS	number	Horizontal post storage shift	A,I
INIT		Initialise keypad	D
INTG		Integrate about voltage datum	D
INVPS		Invert trace after storage	D

LIM	CONT HALT OFF	Test Limits A,I	
LIMST	PASS FAIL	Limit status	I
LOWLIM		Save lower limit	D
MAX		Maximum measured from datum	I
MEAN		Average voltage of trace	I
MIN		Minimum measured from datum	I
OVER		Overshoot percentage	I
PEAK		Peak to peak time	I
PERIOD		Period at datum level	I
PRESH		Preshoot percentage	I
PRINT	ON OFF	Enable/Disable results printout	A,I
REFM		Reference Memory transfer	A,I
REFT		Reference Trace transfer	A,I
RISE		Rise time at 10%,90% points	I
RMHS		Reference memory horizontal scaling	A,I
RMVS		Reference memory vertical scaling	A,I
RMS		RMS value measured from datum	I
RMTYPE		Reference memory type	A,I
RESTORE (VPS)		Recover from last function Vertical position post storage (see 1600 operating manual)	D
RISEPER	0-100	Rise/fall variable bounds	A,I
RUNSEQ		Execute programmable sequence	D
SAVEONE		Save current trace to ref. memory	D
SAVEALL		Save all traces to ref memories	D
SEQU		Programmable sequence transfer	A,I
SETAVG	OFF,2,4,8, 16,32,64, 128,256, 512,1024	Set averaging factor	A,I
SETENV	OFF,2,4,8, 16,32,64, 128,256, CONT	Set enveloping factor	A,I
SETREF		Set dB and %age reference voltage	A,I
TVLINE		number TV line number	A,I
TVSTD	PAL NTSC SECAM	TV standard	A,I
TVMODE	ON OFF	TV mode triggering	A,I
UPLIM		Save upper limit	D
VTMODE		Select volts, time measurement	D
WIDTH		Pulse width at 50% points	I
YCAL	CAL UNCAL	Vertical calibration	I
YMAG	number	Post storage Y magnification	A,I
YSCALE	number	Vertical scaling factor	I

4.2 General

The IEEE/RS423 commands are designed to allow access to the functions of the 260 waveform processor, they operate in the same way as pressing the buttons on the keypad. All the measurement functions which return

a value (i.e. those which are interrogative only) work on data bracket between the time datum and the cursor. The cursor must be selected for the trace on which the measurements are being made (see the CSRTR command in the main operating manual). If the cursors are switched off then measurements will be made on the last selected trace between the first and last data point taking the centre of the screen as the voltage datum. With the exception of rise and fall measurements, it does not matter which way round the cursor and time datum are positioned for selecting the measurement window.

Note that if the selection fails, for example in the case of the DUTY command if no zero crossings are found, then the function will return a value of -1, as well as generating a service request of 100.

The convention used in this manual is the voltage datum is displayed as a horizontal line on the screen and is the reference for voltage measurements, and the time datum is displayed as a vertical line on the screen and is the reference for time measurements.

If required, the measurements of duty cycle, frequency, and period can be made about the centre of the trace. This is done by first using either the MEAN or MAX/MIN functions to determine the centre point, and then setting the voltage datum to this level. For example to measure the frequency of trace 1A:

```
CSRTR =      1A Select trace 1A
DATMH = 0    set datum to left of screen
CRSHP = 10   set cursor to right of screen
MEAN         request mean of trace 1A input mean
             value
DATMV =
  mean value set datum to centre of trace
FREQ         request frequency of trace 1A input
             result
```

4.3 Details of Functions

Function: **RMS value about mean of waveform**

Type: Interrogative

Syntax: ACRMS

Explanation: The RMS value of the selected waveform between the time datum and cursor is measured by first calculating the mean of the waveform. The difference between this level and the waveform for each point, is then squared and the average of these values is then square rooted and returned.

Example: ACRMS
'ACRMS = 2.34' (1600 response)
(RMS voltage is 2.34 Volts)

Note: *If the peak value of the trace between the time datum and cursor lies outside the range of the A/D converter, i.e. if it is off screen, the routine will return a service request 103 as well as a result using the maximum allowable value.*

See also: RMS

Function: **Select destination of trace arithmetic**

Type: Assertive, Interrogative

Syntax: ADEST
ADEST = [trace]

Explanation: Select the destination trace for trace arithmetic operations. The results of future trace arithmetic operations will be stored in this trace.

Example: ADEST = CH2
ADEST
'ADEST = REF1' (1600 response)
(Arithmetic result to Reference trace 1)

See also: AOPND, AROP, ASCALE, ASRC, CALC

Function: **Select second source trace for trace arithmetic**

Type: Assertive, Interrogative

Syntax: AOPND
AOPND = [trace]

Explanation: Select trace arithmetic operand

Example: AOPND = CH3
AOPND
'AOPND = CH4' (1600 response)
(Arithmetic operand is Channel 4)

See also: ADEST, AROP, ASCALE, ASRC, CALC

Function: **Select arithmetic operation**

Type: AROP = [SUM] or [SUB] or [MULT]

Explanation: Select the arithmetic operation (ADD, SUB or MULT) performed by the waveform processor trace arithmetic.

Example: AROP = MULT
AROP
'AROP = SUB' (1600 response)
(Current operation is subtract)

See also: ADEST, AOPND, ASCALE, ASRC, CALC

Function: **Select Trace Multiplication Scaling**

Type: Assertive, Interrogative

Syntax: ASCALE
ASCALE = [1] or [2] or [5] or [10]

Explanation: After a multiplication operation has been performed by the waveform processor trace arithmetic the resulting trace is scaled down by 1, 2, 5 or 10 times.

NOTE:- *this scaling is only applied when AROP = MULT*

Example: ASCALE = 5
ASCALE
'ASCALE = 10' (1600 response)
(Current scaling is 1/10)

See also: ADEST, AOPND, AROP, ASRC, CALC

Function: **Select trace arithmetic source**

Type: Assertive, Interrogative

Syntax: ASRC
ASRC = [trace]

Explanation: Select the first source for trace arithmetic operations.

Example: ASRC = CH3
ASRC
'ASRC = CH4' (1600 response)
(Arithmetic source is channel 4)

See also: ADEST, AOPND, AROP, ASCALE, CALC

Function: **Area under trace**

Type: Interrogative

Syntax: AREA

Explanation: The area under the selected waveform between the time datum and cursor by summing the voltage differences between the trace and the voltage datum. The result is then rescaled into units of Volts Seconds.

Example: AREA
'AREA = 2.34E-6' (1600 response)
(RMS voltage is 2.34μVs)

Note: *If the peak value of the trace between the time datum and cursor lies outside the range of the A/D converter, i.e. if it is off screen, the routine will return a service request 103 as well as a result of zero.*

See also: INTG

Function: **Perform trace arithmetic**

Type: Direct

Syntax: CALC

Explanation: The waveform processor will the arithmetic function (AROP) using the two source traces (ASRC and AOPND) and places the result in the destination trace (ADEST).

Example: CALC

Note: *When the arithmetic operation is complete the waveform processor will return a service request 74.*

See also: ADEST, AOPND, AROP, ASCALE, ASRC

Function: **Perform a Waveform Processor acquisition**

Type: Direct

Syntax: CAPTURE

Explanation: Arms the 1600 to acquire traces. Note that this function acts in the same manner as pressing 'CAPTURE' on the keypad. CAPTURE differs from the ARM command available on the 1600 as it will take into account the current settings of SETAVG and/or SETENV. For example, if SETAVG has been set to 128 beforehand the performing a CAPTURE will perform 128 acquisitions in order to calculate their average.

Example: CAPTURE

Note: *When the capture is complete the waveform processor will return a service request 74.*

See also: SETAVG, SETENV

Function: Select cursor measurement mode

Type: Assertive, Interrogative

Syntax: CMODE
CMODE = [NORMAL] or [RELDAT] or [RELTRC]

Explanation: Selects one of the three voltage and time measurement modes. NORMAL, RELDAT and RELTRC correspond to 'V wrt VOLTAGE DATUM', 'V wrt V AT TIME DATUM' and 'T TO LAST CROSSING POINT' respectively. For more details on the measurements made in these modes see the 'Time and Voltage Measurement' section of this manual.

Example: CMODE = RELDAT
CMODE
'CMODE = RELTRC' (1600 response)
Current cursor mode is
'T TO LAST CROSSING POINT')

See also: CSCALE, SETREF, VTMODE

Function: Select cursor vertical scaling

Type: Assertive, Interrogative

Syntax: CSCALE
CSCALE = [NORMAL] or [DB] or [DBV] or [PER]

Explanation: Selects the vertical scaling of measurements to be volts (NORMAL), dB wrt the reference voltage (DB), dB wrt 1V (DBV) or percentage wrt the reference voltage (PER).

Example: CSCALE = DBV
CSCALE
'CSCALE = PER' (1600 response)
(Percentage scaling is being used for cursor measurements)

See also: CMODE, SETREF, VTMODE

Function: **Duty cycle about voltage datum**

Type: Interrogative

Syntax: DUTY

Explanation: The duty cycle of a waveform is the ratio of the time the waveform is positive to the period of the waveform. this function notes the positions where the waveform crosses the voltage datum and so calculates the duty cycle as a percentage of the period.

Examples: DUTY
'DUTY = 39.1' (1600 response)
(Duty cycle is 39.1%)

Note: *If no cross over points are found then service request 100 will be generated and the value -1 will be returned.*

See also: PERIOD

Function: **Perform a Fourier transform**

Type: Direct

Syntax: FFT

Explanation: Performs a fast Fourier transform on the currently selected trace. For more details see the description of the FFT function in the Post-Storage section of this handbook.

Example: FFT

Note: *When the FFT is complete the waveform processor will return a service request 74.*

See also: FFTHSC, FFTMEAS, FFTPTS, FFTTRC, FFTVSC, FFTWIND

Function: **Select FFT horizontal scaling**

Type: Assertive, Interrogative

Syntax: FFTHSC
FFTHSC = [LIN] or [LOG]

Explanation: Select the format of the frequency spectrum produced by an FFT.

Example: FFTHSC = LOG
FFTHSC
'FFTHSC = LIN' (1600 response)
(Linear output selected)

See also: FFT, FFTMEAS, FFTPTS, FFTTRC, FFTVSC, FFTWIND

Function: **Select the frequency measurement mode for FFT traces**

Type: Assertive, Interrogative

Syntax: FFTMEAS
FFTMEAS = [HARM] or [REL]

Explanation: Selects between harmonic or relative frequency measurement on an FFT trace. Harmonic measurement displays the ratio of the frequency at the time datum to the frequency at the cursor. Relative measurement displays the difference in frequency between the cursor and the time datum.

Example: FFTMEAS = HARM
FFTMEAS
'FFTMEAS = REL' (1600 response)
(Relative measurement selected)

See also: FFT, FFTHSC, FFTPTS, FFTTRC, FFTVSC, FFTWIND

Function: **Select number of points sampled by Fourier transform**

Type: Assertive, Interrogative

Syntax: FFTPTS
FFTPTS = [256] or [512] or [1024] or [CURSOR]

Explanation: Selects the number of points that are considered from the selected trace in order to perform an FFT. If 512 points are selected then every second point of a 1024 point trace is used. Similarly every fourth point for FFTPTS=256. If CURSOR is selected then only those points between the cursor and voltage datum are used.

Examples: FFTPTS = 512
FFTPTS
'FFTPTS = USER' (1600 response)
(Points between cursors selected)

See also: FFT, FFTHSC, FFTMEAS, FFTTRC, FFTVSC, FFTWIND

Function: **Select destination of Fourier transform**

Type: Assertive, Interrogative

Syntax: FFTTRC
FFTTRC = [trace]

Explanation: Selects the destination of the frequency spectrum produced by the Fourier transform.

Example:
```
FFTTRC = CH2
FFTTRC = REF1
FFTTRC
'FFTTRC = REF2' (1600 response)
  (Frequency spectrum will be sent
  to Reference trace 1)
```

See also: FFT, FFTHSC, FFTMEAS, FFTPTS, FFTVSC, FFTWIND

Function: **Select FFT vertical scaling**

Type: Assertive, Interrogative

Syntax:
```
FFTVSC
FFTVSC = [LIN] or [LOG]
```

Explanation: Select the amplitude scaling performed by an FFT process.

Example:
```
FFTVSC = LOG
FFTVSC
'FFTVSC = LIN' (1600 response)
  (Linear output selected)
```

See also: FFT, FFTHSC, FFTMEAS, FFTPTS, FFTTRC, FFTWIND

Function: **Select Fourier Transform window function**

Type: Assertive, Interrogative

Syntax:
```
FFTWIND
FFTWIND = [RECT] or [HANN]
```

Explanation: This command selects which type of window function is applied to a trace prior to performing a Fourier transform. Either a rectangular or Hanning window can be used.

Examples:
```
FFTWIND = HANN
FFTWIND
'FFTWIND = RECT' (1600 response)
  (Rectangular window selected)
```

See also: FFT, FFTHSC, FFTMEAS, FFTPTS, FFTTRC, FFTVSC

Function: **Filter waveform**

Type: Direct

Syntax: FILTER = [1] or [2] or [3] or [4] or [5] or [6]

Explanation: The selected waveform is filtered by one of six digital low pass filters. The effective cutoff frequency of each filter is determined by the timebase setting.

Example: FILTER = 3

Note: *When the filtering operation is completed a service request 74 will be generated. A copy of the data is taken so the RESTORE command will recover the original waveform. If the trace is not stored or held a service request 100 will be generated and no action will be taken.*

Function: **Frequency about voltage datum**

Type: Interrogative

Syntax: FREQ

Explanation: The frequency of the selected waveform between the time datum and cursor is measured by looking for points at which the waveform crosses the voltage datum, from these points the period and hence the frequency of the waveform is calculated.

Example: FREQ
'FREQ = 15.1E+3' (1600 response)
(Frequency is 15.1kHz)

Note: *If no cross-over points are found then service request 100 will be generated and the value -1 will be returned.*

See also: PERIOD

Function: **Waveform processor hello message**

Type: Interrogative

Syntax: HELLOWP

Explanation: This command is used to check the keypad version.

Example: HELLOWP
'HELLOWP = WP260version X.XX'
(1600 response)

See also: HELLO in the 1600 operating manual.

Function: **Horizontal post storage shift**

Type: Assertive, Interrogative

Syntax: HPS
HPS = number

Explanation: After data has been stored or is held, an individual trace can be moved horizontally. This is done by rotating the data through the store, so there will be a discontinuity at the point where the first and last acquisition are placed next to one another. The number in the command is the shift in divisions relative to its initial position, and so it can lie in the range +10.23 to -10.23. Positive numbers indicate a shift to the right, and negative numbers a move to the left. The value read back when the command is used interrogatively is the total shift from the captured position, and so the trace can be restored to its original position by applying equal and opposite shift.

Example: HPS = 2.3
HPS
'HPS = -3.9' (1600 response)
(Currently selected trace is shifted 3.9 divs to the left)

Note: *Since the position before the shift is remembered the RESTORE command will reset the trace to its previous position, i.e. HPS = 0. If the shift required is outside the allowable range a service request 103 will be generated. When the shifting is completed a service request 74 will be generated.*

See also: VPS, SHFT in the 1600 operating manual

Function: **Initialise keypad**

Type: Direct

Syntax: INIT

Explanation: This command is equivalent to pressing the Initialise button on the keypad, and it resets the internal variables to their default settings.

Example: INIT

Note: *When the initialisation is complete a service request 74 will be generated.*

Function: **Integrate trace**

Type: Direct

Syntax: INTG

Explanation: The selected trace is integrated with respect to time, the voltage zero is taken to be the voltage datum. The result is automatically scaled and the scaling factor is retained so that the cursors read correctly. This factor can be read out using the YSCALE command.

Example: INTG

Note: *When the integration is completed a service request 74 will be generated. A copy of the data is taken so the RESTORE command will recover the previous trace. If the trace is not stored or held a service request 100 will be generated and no action will be taken.*

See also: YSCALE

Function: **Invert trace post storage**

Type: Direct

Syntax: INVPS

Explanation: This command inverts the trace about the voltage datum and is equivalent to pressing the invert button on the keypad. A record of the original trace is taken and so the RESTORE command will recover the last action of this function. The sign of YSCALE is changed to record the fact that the trace has been inverted.

Example: INVPS

Note: *When the invert is complete a service request 74 will be generated. If the trace is not stored or held a service request 100 will be generated and no action will be taken.*

Function: **Limit test mode**

Type: Assertive

Syntax: LIM
LIM = [OFF] or [CONT] or [HALT]

Explanation: The limit testing works by comparing the trace in one channel with reference trace 1.

The reference trace memory 1 holds both the upper and lower limits by using alternate sample points. For example if the test waveform in trace 1A must lie between a data value of 50 and 110, then reference trace

1 should contain the data:

50, 110, 50, 110, 50, 110 .....

The limit waveform can be transferred to and from the computer (see the sending and receiving stores section of the 1600 operating manual). If required, the upper and lower limits can be set from the corresponding sweep (see LOWLIM and UPLIM).

The channel to be tested is selected using the cursors. The section of the waveform on which the limit test is performed is defined by the time datum and cursor.

The LIM command is used to select the operating mode for limits testing.

There are two possible modes:

Continuous: Data is continuously acquired and tested. The result is displayed or read out as PASS or FAIL.

Halt: Data is acquired and tested. When the test is failed acquisition stops.

The result of the test can be read out using the LIMST command.

Example: LIM = CONT
LIM = OFF
LIM
'LIM = HALT' (1600 response)
(Acquisition will stop if selected trace falls outside limit)

See also: LIMST, LOWLIM, UPLIM

Function: Limit test status

Type: Interrogative

Syntax: LIMST

Explanation: This command is used to read the result of the limit test. The response will be PASS if the trace under test is within the limits defined by the limit waveform and the time datum and cursor, and it will be FAIL if any data point lies outside these limits. If the limit test mode is HALT the response will be PASS until a trace has failed and been stored, when the response will be FAIL.

Example: LIMST
'LIMST = PASS' (1600 response)
(trace is within limit)

Note: *If no limits testing has been selected using the LIM command a service request 100 will be generated.*

See also: LIM, LOWLIM, UPLIM

Function: Save lower limit

Type: Direct

Syntax: LOWLIM

Explanation: This command is equivalent to pressing the Save Lower Limit button on the keypad and is used to set up the lower limit for limits testing. This is held in reference trace 1. LOWLIM will save the selected trace in the correct form for limits testing.

Example: LOWLIM

Note: *When the transfer is complete a service request 74 will be generated,'*

See also: UPLIM, LIM, LIMST, HMOD

Function: Maximum measured from datum

Type: Interrogative

Syntax: MAX

Explanation: This command returns the maximum value of the trace in volts measured from the voltage datum. If the section of the waveform selected by the time datum and cursor is below the voltage datum then the result will be negative.

Example: MAX
'MAX = 54E-2' (1600 response)
(Maximum value is 54m Volts)

Note: *If the peak value of the trace between the time datum and cursor lies outside the range of the A/D converter, i.e., if it is off screen, the routine will return a service request 103 as well as a result using the maximum allowable value.*

Function: Mean of trace

Type: Interrogative

Syntax: MEAN

Explanation: This command returns the mean value of the trace between the time datum and cursor in divisions. It can be used to find the centre of an ac waveform prior to measuring duty cycle, period or frequency.

Example: MEAN
'MEAN = 2.4' (1600 response)
(Mean value is 2.4)

Note: *If the peak value of the trace between the time datum and cursor lies outside the range of the A/D converter, i.e., if it is off screen, the routine will return a service request 103 as well as a result using the maximum allowable value.*

See also: MAX

Function: Minimum relative to datum

Type: Interrogative

Syntax: MIN

Explanation: This command returns the minimum value of the waveform in volts measured from the voltage datum. If the section of the waveform selected by the time datum and cursor is above the voltage datum then the result will be negative.

Example: MIN
'MIN = 55.4E-3' (1600 response)
(Maximum value is 55.4m Volts)

Note: *If the peak value of the trace between the time datum and cursor lies outside the range of the A/D converter, i.e., if it is off screen, the routine will return a service request 103 as well as a result using the maximum allowable value.*

See also: MAX

Function: Enable and disable measurement scrolling

Type: Assertive, Interrogative

Syntax: MSCROLL
MSCROLL = [ON] or [OFF]

Explanation: Enables the scrolling up the screen of successive cursor measurements. Note this mode only operates during the execution of a programmable sequence.

Example: MSCROLL = ON
MSCROLL
'MSCROLL = OFF' (1600 response)
(Measurement scrolling is disabled)

See also: PRINT

Function: Overshoot

Type: Interrogative

Syntax: OVER

Explanation: The overshoot of an edge is measured between the time datum and the cursor. The 0% and 100% points are taken as the points where the time datum and the cursor cross the waveform. The overshoot is the ratio of the maximum point between the time datum and cursor and the voltage difference between the time datum and cursor expressed as a percentage.

There are a number of different possible measurements which can be made, depending on the relative positions of the time datum and cursor:

Condition	Measurement
1: Rising edge, datum to left of cursor	Overshoot
2: Falling edge, datum to left of cursor	Undershoot

Example: OVER
'OVER = 21.9' (1600 response)
(Overshoot is 21.9%)

Note: *If the peak value of the waveform between the time datum and cursor lies outside the range of A/D converter, i.e., if it is off screen, the routine will return a service request 103 and return a result of 100%.*

See also: RISE, MAX, MIN, PEAK

Function: Period at voltage datum

Type: Interrogative

Syntax: PERIOD

Explanation: The period of the selected waveform between the time datum and cursor is measured by looking for points at which the waveform crosses the voltage datum, and then calculating the period allowing for incomplete cycles.

Example: PERIOD
'PERIOD = 53.4E-6' (1600 response)
(Period is 53.4μsec)

Note: *If no cross-over points are found then service request 100 will be generated and the value -1 will be returned.*

See also: FREQ

Function: **Preshoot**

Type: Interrogative

Syntax: PRESH

Explanation: The overshoot of an edge is measured between the time datum and the cursor. The 0% and 100% points are taken as the points where the time datum and the cursor cross the waveform. The overshoot is the ratio of the minimum point between the time datum and cursor and the voltage difference between the time datum and cursor expressed as a percentage.

Example: PRESH
'PRESH=18.2' (1600 response)
(Preshoot is 18.2%)

Note: *If the peak value of the waveform between the time datum and cursor lies outside the range of A/D converter, i.e., if it is off screen, the routine will return a service request 103 and return a result of 100%.*

See also: OVER

Function: **Enable or disable measurement line printing**

Type: Assertive, Interrogative

Syntax: PRINT
PRINT = [ON] or [OFF]

Explanation:

Example: PRINT = ON
PRINT
'PRINT = OFF' (1600 response)
(Measurement printout is disable)

See also: MSCROLL

Function: **Reference memory transfer**

Type: Assertive, Interrogative

Syntax: REFM*
REFM (number)
REFM (number) = [datafield], [TRC1A], [TRC2A], [TRC3A], [TRC4A]

Explanation: The command takes one basic interrogative form which allows the transfer of a reference memory to the host computer. The number of the reference memory depends upon the current mode. The two modes are 50 × 1K or 5 × 10K reference

memories. Consequently the two valid ranges are REFM(1-50) or REFM(1-5). The REFM* form of this command will transfer all reference memories in the current mode.

The two basic assertive forms will again operate with any valid reference memory number for the current mode.

The format of the data field is dependent on the specified block length. If BLL = 0 then this will consist of 1024 numbers in the specified base followed by ‹cr› ‹lf› with EOI on the ‹lf›. If BLL is non zero then the data field will consist of a number of blocks, each separated by a ‹cr› ‹lf› with EOI on the last ‹lf› if asserted.

Examples: REFM*
REFM5
REFM17
REFM23 = TRC3A

See also: EOI, BL, BLL, NB, WIND, in the 1600 operating manual.

Note: *Service request 103 will be generated if the number is out of range. Service request 102 will be generated for a syntax error.*

Function: Reference trace transfer

Type: Assertive, Interrogative

Syntax: REFT*
REFT1
REFT2
REFT1 = [data field],[reference memory number],
[TRC1A], [TRC2A], [TRC3A], [TRC4A]

Explanation: The operation of this command will supercede the same command existing in the IEEE/RS423 option. The command takes three interrogative forms (REFT*, REFT1, REFT2) these will transfer the data from either both or one reference trace to the host computer. Each reference trace store consists of 1024 data samples, the first being for the left-hand edge of the screen and the next successive one for the position further right, each time.

There are three assertive forms of the command which will operate with either reference trace. These allow bulk transfer of data from the host to a reference trace, transfer of a reference memory to a reference trace and transfer of a trace to a reference memory.

The format of the data field is dependent on the specified block length. If BLL = 0 then this will consist of 1024 numbers in the specified base followed by ‹cr› ‹lf› with EOI on the ‹lf›. If BLL is non zero then the data field will consist of a number of blocks each separated by a ‹cr› ‹lf› with EOI on the last ‹lf› if asserted.

The range of the reference memory numbers is dependent on the current modes. The two modes are 50 or 1K or 50 × 10K reference memories. Consequently the two valid ranges are REFM(1-50) or REFM(1-5).

Examples: REFT1 = TRC1A
REFT*
REFT2 = REFM7

Note: *Service request 103 will be generated if the number is out of range. Service request 102 will be generated for a syntax error.*

See also: EOI, BL, BLL, NB, WIND in the 1600 operating manual.

Function: Rise time of a waveform

Type: Interrogative

Syntax: RISE

Explanation: The rise time of the waveform is measured between the percentage points as set by the RISEPER command. The 0% point is defined by the point where the time datum crosses the trace, and the 100% point is defined by the value at the cursor position. Working from the time datum, the routine will accept the first points at which the waveform crosses the higher percentage value. If the 0% is greater than the 100% level then the fall time is calculated in the same way as the rise time.

Example: RISE
'RISE = 832E-9' (1600 response)
(Rise/Fall time is 832 nsec)
RISE
'RISE = 532E-6' (1600 response)
(Rise/Fall time is 532 μsec)

Note: *If the peak value of the waveform lies outside the range of the A/D converter, i.e., if it is off screen, the waveform processor will return a service request 103 as well as a value of -1.*

See Also: RISEPER

Function: **Select bounds for rise/fall measurement**

Type: Assertive, Interrogative

Syntax: RISEPER
RISEPER = [number]

Explanation: The percentage bounds used in the calculation of the rise/fall value are set using this command. The default values set at power up are 10%,90%.

Example: RISEPER = 20,80
RISEPER
'RISEPER = 15,85' (1600 response)
(Current bounds are 15% and 85%)

See also: RISE

Function: **Reference memory horizontal scaling**

Type: Assertive, Interrogative

Syntax: RM (number) HS
RM*HS
RM (Number)HS = [timebase range]

Explanation: The command takes one basic interrogative form which gives the timebase value that was valid when the trace was stored. The number of the reference memory depends upon the current mode. The two modes are 50 × 1K or 5 × 10K reference memories. Consequently the two valid ranges are (1-50) or (1-5). The RM*HS form of this command will give all the associated timebase values for each reference memory in the current mode. The assertive form of this command allows a particular reference memory's timebase value to be altered. The timebase range is 50μs to 200s per division in 1, 2, 5 steps.

Examples: RM3HS
RM*HS
RM7HS = 100E-6

NOTE: *Service request 102 will be generated for a syntax error.*

Function: **Reference memory vertical setting**

Type: Assertive, Interrogative

Syntax: RM(number)VS
RM*VS
RM(number)VS = [vertical setting]

Explanation: The command takes one basic interrogative form which gives the vertical settings that were valid when the trace was stored. The number on the reference memory depends on the current mode. The two modes are 50 × 1K or 5 × 10K reference memories. Consequently the two valid ranges are (1-50) or (1-5). The RM*VS form of this command will give all the associated vertical settings for each reference memory in the current mode. The assertive form of this command allows a particular reference memory's vertical settings to be altered.

The vertical setting takes the form of:-

- Trace Inverted
› Variable, uncalibrated
~ AC coupled

Trace inverted, variable and ac coupled are optional. The vertical range is 2mV to 10V per division in 1,2,5 steps.

Example: RM23VS
RM*VS
RM43VS = -10E-2~
(set to inverted 100mV DIV ac coupled.)

Function: RMS value about voltage datum

Type: Interrogative

Syntax: RMS

Explanation: The RMS value of the selected waveform between the time datum and cursor is measured taking the voltage datum as the zero level. The difference between this level and the waveform, for each point is squared and the average of these values is then square rooted and returned as the result.

Example: RMS
'RMS = 12.34' (1600 response)
(RMS Voltage is 12.34 Volts)

Note: *If the peak value of the trace between the time datum and cursor lies outside the range of the A/D converter, i.e., if it is off screen the routine will return a service request 103 as well as a result using the maximum allowable value.*

See also: ACRMS

Function: **Reference memory type**

Type: Assertive, Interrogative

Syntax: RMTYPE
RMTYPE = [5] or [50]

Explanation: This command takes one basic interrogative form which gives the current reference memory type. There are two configurations of reference memories, either 50 × 1K or 50 × 10K. The reference memory type is 5 for 5 × 10K memories or 50 for 50 × 1K memories. The assertive form of this command allows the reference memory configuration to be altered between types.

Example: RMTYPE = 50
RMTYPE
RMTYPE = 5' (1600 response)

Note: *Service request 103 will be generated for numbers out of range.*

Function: **Restore original trace**

Type: Direct

Syntax: RESTORE

Explanation: This command is equivalent to pressing the Restore button on the keypad. It returns the trace to the condition it was in before the last waveform manipulation. The functions which can be recovered in this way are:

HPS, INT, INVPS, YMAG, FILTER

Example: RESTORE

Function: **Execute the current programmable sequence**

Type: Direct

Syntax: RUNSEQ

Explanation: The programmable sequence currently stored in the waveform processor is executed.

Example: RUNSEQ

Note: *When the execution of the sequence is complete the waveform processor will return a service request 74.*

See also: SEQU

Function: **Save trace to reference memory**

Type: Direct

Syntax: SAVEONE

Explanation: The trace currently selected by the cursor is saved to the current reference memory. The reference memory pointer is then moved on to the next reference memory.

Example: SAVEONE

See also: SAVEALL, REFM*

Function: **Save displayed traces to reference memories**

Type: Direct

Syntax: SAVEALL

Explanation: All currently displayed traces are saved in consecutive reference memories. The reference memory pointer is then moved on to the next reference memory.

Example: SAVEALL

See also: SAVEONE, REFM*

Function: **Save or recall a programmable sequence**

Type: Assertive, Interrogative

Syntax: SEQU = n,b1,b2,b3,b4,...,bm
SEQU

Explanation: When used interrogatively the 1600 will send a sequence of numbers that represent the current set of programmable sequence steps. Sequences of this type can be returned to the 1600 using the assertive format of this command. NOTE:- a programmable sequence saved in this way is a string of numbers similar to a machine setup, NOT a textual representation of the programmable sequence. No attempt should be made to send a sequence that has been created other than by the 260 Waveform Processor. SEQU is intended only as a means of saving and recalling programmable sequences.

See also: RUNSEQ

Function: **Set averaging factor**

Type: Assertive, Interrogative

Syntax: SETAVG
SETAVG = [number]
where number is one of 2, 4, 8, 16, 32, 64, 128, 256, 512 or 1024

Explanation: Used to set or return the number of acquisitions CAPTURE will perform in order to create an averaged trace.

Example: SETAVG = 128
SETAVG
'SETAVG = 8' (1600 response)
(Averaging factor is 8 traces)

See also: CAPTURE, SETENV

Function: **Set enveloping factor**

Type: Assertive, Interrogative

Syntax: SETENV
SETENV = [number]
where number is one of 2, 4, 8, 16, 32, 64, 128, 256 or CONT

Explanation: Used to set or return the number of acquisitions CAPTURE will perform in order to compile an envelope of the maximum and minimum values.

Example: SETENV = 256
SETENV
'SETENV = 16' (1600 response)
(Enveloping factor is 16 traces)

See also: CAPTURE, SETAVG

Function: **Set reference voltage**

Type: Assertive, Interrogative

Syntax: SETREF
SETREF = [number]

Explanation: Sets the reference voltage for dB and percentage measurements. For more details of these and other measurement modes see the 'Waveform Measurements' section of this manual

Example: SETREF=1E-3 sets the reference voltage to 1 millivolt
SETREF
'SETREF = 0.287' (1600 response)
(Reference voltage is 287 millivolts)

NOTE:- *if the 1600 is uncalibrated then values are given or interpreted in terms of divisions.*

See also: CSCALE

Function: Select TV line number

Type: Assertive, Interrogative

Syntax: TVLINE
TVLINE = number

Explanation: This command is used to select the number of the line to be acquired when in TV capture mode. The maximum value of the number of lines will be determined by the setting of TVSTD.

Example: TVLINE = 123
TVLINE
'TV LINE = 367' (1600 response)
(TV line 367 currently selected)

Note: *If the line number selected falls outside the allowable range then a service request 103 will be generated and the command will be ignored.*

See also: TVSTD, TVMODE

Function: Select TV standard

Type: Assertive, Interrogative

Syntax: TVSTD
TVSTD = [PAL] or [NTSC] or [SECAM]

Explanation: This command selects the TV standard which will be used for the acquisition of TV lines.

Example: TVSTD = PAL

See also: TVMODE, TVLINE

Function: Select TV triggering

Type: Assertive, Interrogative

Syntax: TVMODE
TVMODE = [ON] or [OFF]

Explanation: This command sets up the triggering correctly for capturing TV lines. It is equivalent to pressing the TVMODE button on the keypad.

Once TVMODE has been set to ON then setting TVMODE to OFF will return the trigger system to its state before the TVMODE = ON was issued.

Example: TVMODE = ON
TVMODE
'TVMODE = OFF' (1600 response)
(TV trigger mode not selected)

See also: TVSTD, TVLINE

Function: Save upper limit

Type: Direct

Syntax: UPLIM

Explanation: This command is equivalent to pressing the Save Upper Limit button on the keypad and is used to set up the upper limit for limits testing. The upper limit is held in the reference trace 1 UPLIM will save the selected trace in the correct form for limits testing.

Example: UPLIM

Note: *When the transfer is complete a service request 74 will be generated.*

See also: LOWLIM, LIM, LIMST, HMOD

Function: Select standard measurement mode

Type: Direct

Syntax: VTMODE

Explanation: Resets the cursor measurement mode to 'V wrt VOLTAGE DATUM' and the cursor scaling to 'NORMAL'. These are the default measurement types selected when the 1600 is switched on.

Example: VTMODE

See also: CMODE, CSCALE

Function: Pulse width at 50%

Type: Interrogative

Syntax: WIDTH

Explanation: The pulse width of the selected waveform between the time datum and cursor is measured by first performing a max/min function on the waveform. The 50% level is then calculated and the time between the two points at which the waveform crosses this level is measured.

Example: WIDTH
'WIDTH = 57.6E-6' (1600 response)
(Pulse width is 57.6μsec)

Note: *If no cross over points are found then service request 100 will be generated and the value -1 will be returned.*

Function: Vertical calibration

Type: Interrogative

Syntax: YCAL

Explanation: This command is used to determine if a trace is calibrated or uncalibrated. The two possible responses which can be returned are CAL and UNCAL. If the trace was captured using the variable gain or if the trace has been magnified after storage the response will be UNCAL, otherwise the response will be CAL. If the trace is CAL then the results measurements will be in Volts, and if the trace is UNCAL the results will be in divisions.

Example: YCAL
'YCAL = CAL' (1600 response)
(Trace is calibrated)

See also: YMAG, VG*

Function: Post Storage Y magnification

Type: Assertive, Interrogative

Syntax: YMAG
YMAG = number

Explanation: After data has been stored or held, an individual trace can be expanded or reduced vertically about the voltage datum. The maximum allowable range for magnification is 0.062 to 4.0 and this is achieved in 63 steps so the resolution of the magnification factor is 0.06. A copy of the original trace is retained when each magnification is performed, so all magnification factors are relative to the previous trace and not the currently displayed one. For example, requesting a YMAG of 2 followed by a YMAG of 3 on a trace which was 1 division

peak to peak. The RESTORE command will reset the trace to its original magnification, i.e., YMAG = 1. The total magnification can be read out using the YSCALE command.

Example: YMAG = 2
YMAG
'YMAG = 0.5' (1600 response)
(Currently selected trace is reduced by a factor of 2)

Note: *When the magnification is complete the waveform processor will return a service request 74. If a magnification is requested outside the allowable range a service request 103 will be generated. If the trace is not stored or held a service request 100 will be generated and no action will be taken.*

Function: Vertical Scaling factor

Type: Interrogative

Syntax: YSCALE

Explanation: This command is used to read out the overall scaling of the trace after various waveform processing functions have been performed. It is the number by which the current trace must be multiplied to return to the original. If no functions have been performed then YSCALE = 1, so this can be used to check whether the results of the measurement are in divisions or Volts. The functions which affect YSCALE are INTG, YMAG and INVPS.

Example: YSCALE
'YSCALE = 1.76' (1600 response)
(Trace has been reduced by 1.76)

See also: INTG, YMAG, YCAL, INVPS

5. INSTALLATION

The upgrade kit comprises a 260 Waveform Processor Interface and 260 Waveform Processor.

INSTRUCTIONS:

a. Disconnect the mains power from the 1600.

b. Connect to two mounting lugs on the processor into holes on the rear panel.

c. Rotate the module until the connectors mate.

d. Use the fixing screw to connect the module securely to the rear panel.

e. Connect the 260 Waveform Processor to the module using the connector.

f. Reconnect the mains power and switch on.

g. The message during the self test routine should be "Version X.xx + Keypad X.xx".

6. CIRCUIT DESCRIPTION

The 260 Waveform Processor option comprises two printed circuit assemblies and their respective housings, connected by a four wire flexible cable. Assembly 457514, the Processor Interface, is the "pod" which mounts on the rear of the 1600. Assembly 457511, the Waveform Processor, is the "keypad".

I. THE POD

Printed circuit assembly 477660.
When a waveform processor is used, the interface pod provides the necessary paged ROM (keypad software) and RAM for running keypad routines.

Paging & Address Decoding

U1 is a paging latch, whose outputs form extra address lines for the RAM and ROM as well as being decoded by U7 to generate RAM chip selects. U6 and U7 perform address decoding such that the RAM exists as 8K pages from 2000X to 3FFFX. While the ROM exists as 16K pages from 4000X to 7FFFX.

Memory

U3 and U4 are both 32K × 8 static RAM's, organised as eight 8K pages.

U2 is a ROM; PCB links (see circuit diagram) allow the use of different size ROM's up to 27512 (64k × 8), which would be organised as four 16K pages.

Realtime Clock

U5 is a realtime clock. It requires a stretched cycle access to allow the processor to communicate to its registers, and this is handled on the instrument itself. The real-time clock is selected by the signal RTC STRB.

Battery Back Up

Q1, Q2 and associated components detect a loss of 5V. The Ni-Cad battery is then switched in. Due to the requirements of the RT clock U5, under power down conditions +5V becomes OV and OV becomes -3V. In addition to the RAM (U3, U4) and RT clock, U7 is backed up. This ensures the RAM is de-selected during power down, so preserving data.

II. KEYPAD

Printed Circuit assembly 477650 consists of a keyboard encoder circuit. U2 is a crystal controlled baud rate generator which provides a 3.68MHz, Shift clock and a 9.6kHz Baud rate clock to U1, the encoder. U1 detects and debounces key presses. These are encoded and set to the oscilloscope as RS232 signals at TTL voltage levels. This serial data goes via the interface unit to a serial decoder in the main instrument.

7. FAULT FINDING

I. POD AND CABLE

Memory

RAM and ROM address decoding is controlled by a paging latch (U1) and decode logic (U6, U7); as set out in the circuit description above. Functionality of this may be checked using an oscilloscope. If this is OK then the fault may be a broken or intermittent connection. The RAM and ROM sockets should be carefully checked for continuity. Finally the RAM and ROM devices may be checked by substitution.

Battery Back Up

When the instrument is powered down the RT clock (U5) and RAM's are backed up by means of the battery B1.

Battery voltage should be approx. 3.6V and is charged by R4 from the 5V supply. When the supply drops below 4.5V, Q1 switches off and switches Q2 off. Due to the requirements of the RT clock the battery is arranged to power the devices from 0 and -3V, measured relative to 0V on the instrument.

Voltages around R4, D4 may be used to check the battery and charging circuit. Otherwise suspect Q1, Q2 and associated components.

Cable and Connector

This is best checked by a continuity test from the keypad to the pod connector (PLKP).

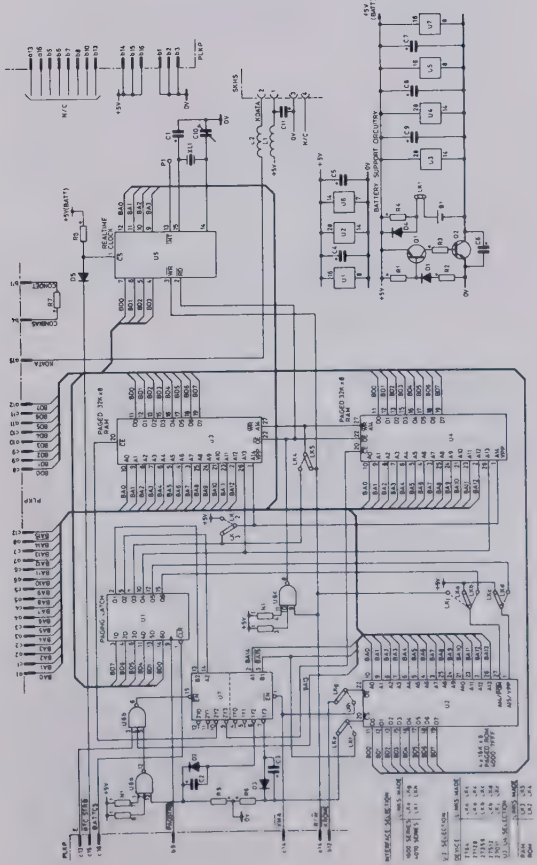
Serial data originates at U1 pin 8 on the keypad; it goes via the cable and SKH5 pin 2 on the pod to pin a15 on the pod connector PLKP.

II. Keypad

Check
U2 pin 11 - 3.68MHz TTL levels
U2 pin 4 - 9.60kHz TTL levels

Check that serial data is transmitted from U1 pin 8. Each key should produce a different 8 bit code. If particular keys do not work there may be a row, column or key fault. If no keys work then suspect U1.

8. CIRCUIT DIAGRAMS AND COMPONENTS LISTS



260 KEYPAD CCT

Ref	*Value*	*Desc*	*Tol*	*Part*
RESISTORS				
R1	10M		10 ¼W	32661
CAPACITORS				
C1	4.7nF		50V	42440
C2	100nF		50V	43498
C3	100nF		50V	43498
C4	47μF	E	10V	457267
INTEGRATED CIRCUITS				
U1		KR9602		456219
U2		MC145411P		456218
MISCELLANEOUS				
XL1		Crystal 3.6864MHz		455607

260 PROCESSOR INTERFACE

RESISTORS

R1	4k7		5	⅛W	44232
R2	2k2		5	⅛W	43357
R3	2k2		5	⅛W	43357
R4	1k		5	⅛W	44226
R5	2k2		5	⅛W	43357
R6	2k2		5	⅛W	43357
R7	3k3		5	⅛W	43358
R8	10k		5	⅛W	44235
N1		Res. Net. 10k x 8 SIL			450452

CAPACITORS

C1	22pf		10	50V	452147
C2	100pF		10	50V	452155
C3	100pF		10	50V	452155
C4	10nF		10	50V	452179
C5	10nF		10	50V	452179
C6	100nF		+80/ -20	50V	43498
C7	10nF		10	50V	452179
C8	10nF		10	50V	452179
C9	10nF		10	50V	452179
C10		TRIM			453867

DIODES

D1	ZENER	3V6	33924
D2	IN4148		23802
D3	IN4148		23802
D4	IN4148		23802
D5	IN4148		23802

INTEGRATED CIRCUITS

U1	74HC174	453806
U2	EPROM	480551
U3	RAM 32k x 8	456183
U4	RAM 32k x 8	456183
U5	MM58274	456184
U6	74HC10	451960
U7	74HC139	452562

MISCELLANEOUS

Q1	2N2907A	452864
Q2	2N2222A	452863
XL1	Crystal 32.768kHz	456182
LK1	Short Bridge	453877
LK3	Short CCT. Link	450315
LK5	Short CCT. Link	450315
LKB	Short CCT. Link	450315

LKD		Short CCT. Link	450315
LKE		Short CCT. Link	450315
LKG		Short CCT. Link	450315
L1	68μH	Choke	454621
L2	3.3μH	Choke	40490
PLKP		48 Way TIL	455859
SKHS		Jack PCB Modular	456151

9. GUARANTEE AND SERVICE FACILITIES

Service Facilities

Gould and its distributors and agents maintain comprehensive after sales facilities and, whether or not it is still under guarantee, the instrument should be returned to the local Gould service centre or distributor through whom it was supplied for servicing if this is necessary. The type and serial number of the instrument should always be quoted, together with full details of any fault and service required.

Equipment returned for servicing must be adequately packed, preferably in the box in which the product was supplied and shipped, with transportation charges prepaid. We accept no responsibility for instruments arriving damaged.

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INDEX

Section
◄ (CURSOR LEFT) 2.1.1
► (CURSOR RIGHT) 2.1.1
◄ (DATUM LEFT) 2.1.1 2.0.3 2.3.5
► (DATUM RIGHT) 2.1.1 2.0.3 2.3.5
▼ (DATUM DOWN) 2.1.1 2.0.3 2.3.5
▲ (DATUM UP) 2.1.1 2.0.3 2.3

ABORT 2.2.6 2.2.7 3.2 3.3
acquiring traces 2.2
adding programmable sequence steps 3.6 3.7
AREA 2.4.8
area measurement 2.4.8
arithmetic operations on waveforms 2.3.9
auto capture and save 2.5.4
averaging 2.2.6

CAPTURE 2.2.1 2.2.6 2.2.7 3.2
CAPTURE AND REPEAT 2.2.2 2.3.8 2.3.9 3.5
circuit description 6
circuit diagrams 8
connecting the waveform processor 2.0.1
CURSOR 2.1.1
cursor 2.1.1
CURSOR MODE 2.1.2

DATUM 2.1.1
datum movement 2.1.1 2.0.3 2.3.5
dB scaling/measurement 2.4.9
dB/% 2.4.9
DEC 2.2.4 2.3.2
DELETE 3.6 3.1
deleting programmable sequence 3.6
deleting programmable sequence steps 3.6

EDIT 3.6 3.7 3.1
editing programmable sequence 3.6 3.4 3.1
entering programmable sequences 3.6 3.7
enveloping 2.2.7
EXECUTE 3.2 3.3 3.6 3.1
executing programmable sequence 3.2 3.3 3.6 3.1
EXIT 3.1

F (function) 2.0.2
fall time measurement 2.4.1
fault finding 7
FFT 2.3.8

FFT MENU 2.3.8 3.8
FILTER 2.3.4
filtering 2.3.4
Fourier transforms 2.3.8
Fourier transform menu 2.3.8
FREQUENCY 2.4.4
frequency measurement 2.4.4
frequency measurement (after FFT) 2.3.9

guarantee 9

Hanning window (FFT) 2.3.8

IEEE commands 4
IEEE control 4
INC 2.2.4 2.3.2
INITIALISE 2.0.2
installing the waveform processor 5 2.0.1
INTEGRATE 2.3.7
integration 2.3.7
INVERT 2.3.6

LEARN 3.1 3.6
limits testing 2.2.5
listing measurements on plotter 2.4.10
listing programmable sequences 3.6.1

magnification/attenuation 2.3.1
MATH MENU 2.3.9 3.8
MAX/MIN 2.4.5
maximum and minimum measurements 2.4.5
measurement scroll 3.9 3.6
measurements 2.4
MENU (FFT) 2.3.8
MENU (MATH) 2.3.9

NEXT 3.3 3.6 3.1
numeric keys 2.0.3

operation 2.0
option functions menu 2.5
OVERSHOOT 2.4.2
overshoot measurement 2.4.2

peak to peak voltage measurement 2.4.6
percentage scaling/measurement 2.4.9
PK/PK (PEAK TO PEAK) 2.4.6
PLOT 2.4.11 3.6.1
plotting waveforms 2.4.11

POSITION 2.3.5
post storage functions 2.3
preshoot measurement 2.4.2
PREV 3.6 3.1
PRINT ON/OFF 2.4.10 3.6.1
programmable sequences 3
adding sequence steps 3.6 3.7
deleting sequence 3.6
deleting sequence steps 3.6
editing sequence 3.6 3.7
entering sequences 3.7 3.6 3.1
executing sequence 3.2 3.3 3.6 3.1
listing sequences 3.6.1
measurement scroll 3.9 3.6
single stepping sequence 3.3 3.1
PULSE WIDTH 2.4.3
pulse width measurement 2.4.3
rectangular window 2.3.8
reference memories 2.5
auto capture and save 2.5.4
clearing 2.5.6
recall from 2.5.2
saving to 2.5.1
selection 2.5.3
size 2.5.5
reference voltage for dB/% measurement 2.4.9

RESTORE 2.3.10
rise fall percentage 2.4.1
RISE TIME 2.4.1
rise time measurement 2.4.1
RMS 2.4.7
RMS measurement 2.4.7
RS423 commands 4
RS423 control 4

S/STEP 3.3 3.1
SAVE ALL 2.5.7
SAVE LOWER LIMIT 2.2.5
SAVE ONE 2.5.7
SAVE UPPER LIMIT 2.2.5
SELECT TRACE 2.1.1
service facilities 9
SET % 2.4.1
SET AVERAGE 2.2.6 2.2.1
SET ENVELOPE 2.2.7 2.2.1
SET REF 2.4.9
single stepping programmable sequence 3.3 3.1
specification 1

TEST LIMITS 2.2.5
time datum 2.1.1
time measurement 2.1.2
tv capture 2.2.3
TV LINE 2.2.4
tv line selection 2.2.4
TV MODE 2.2.3

V&T 2.1.3
voltage datum 2.1.1 2.1.2
voltage measurement 2.1.2

WAIT 2.2.8 3.10
waveform measurements 2.4
windows (FFT) 2.3.8

Y MAG 2.3.1

45750	1	2	3	4	5	6	7	8	9	10

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